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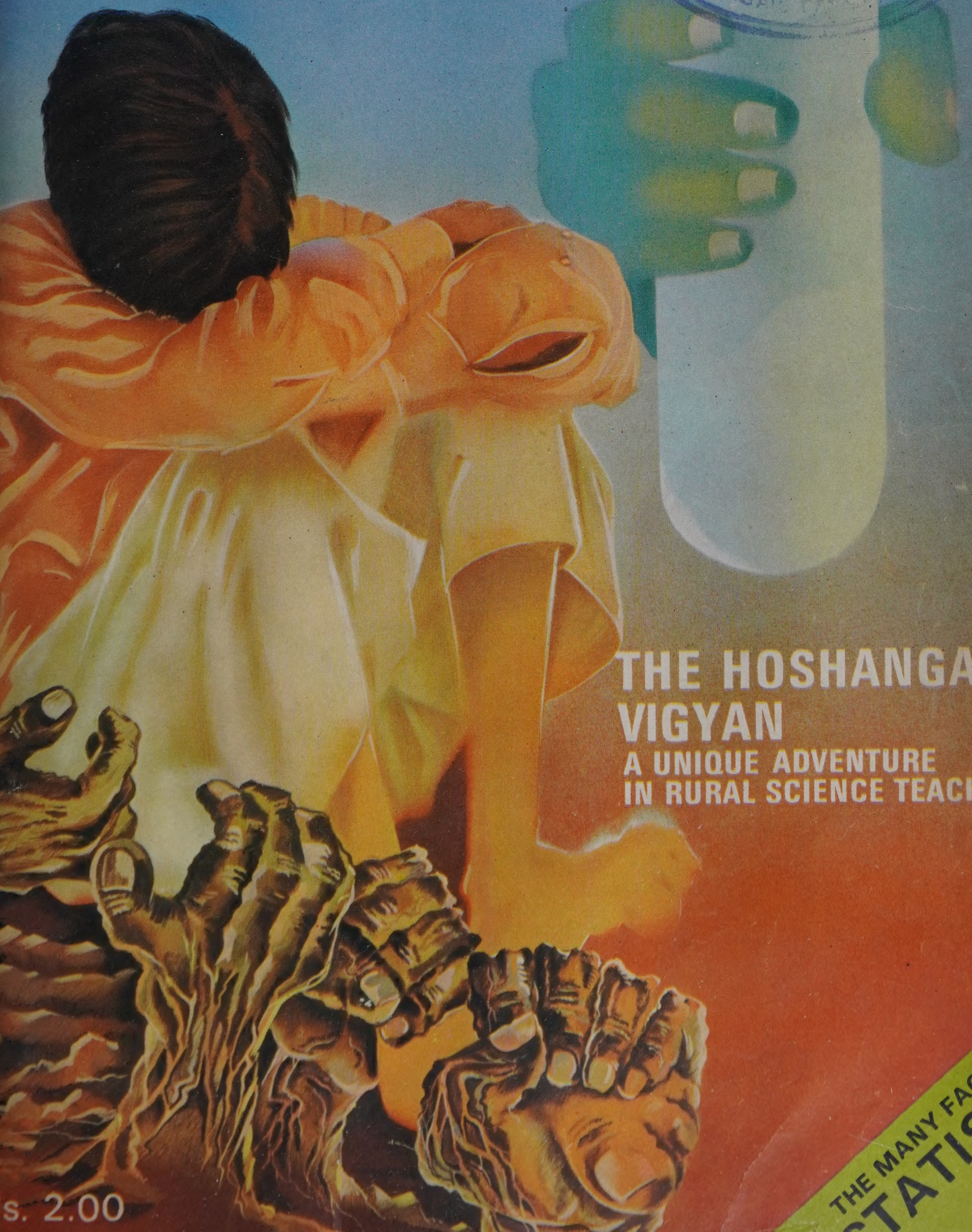

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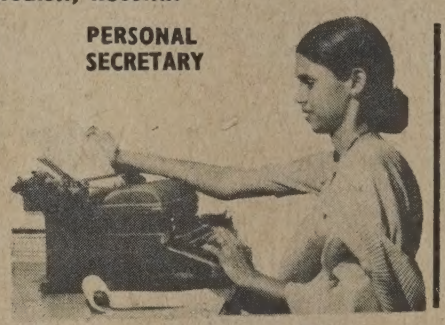

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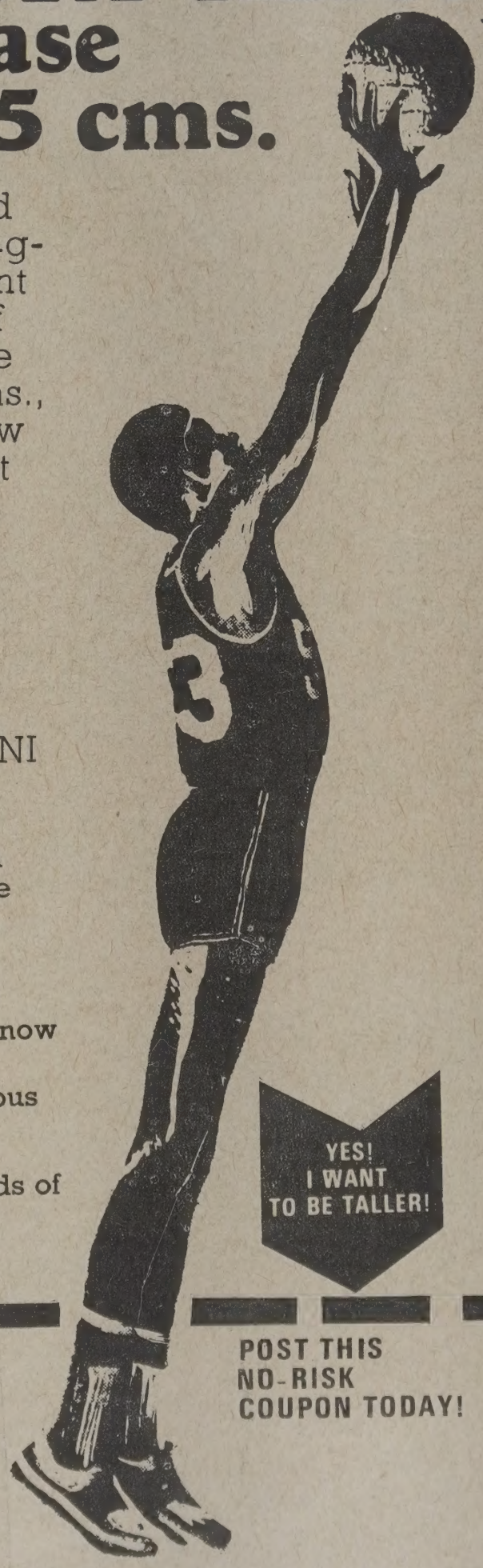

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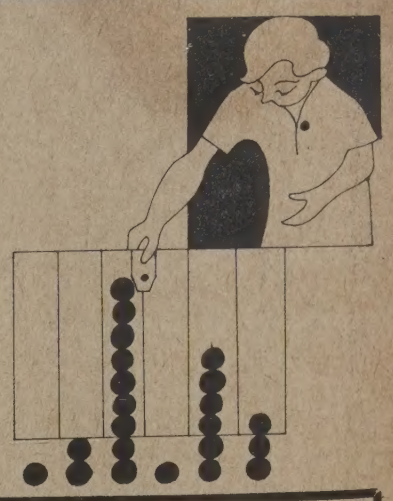

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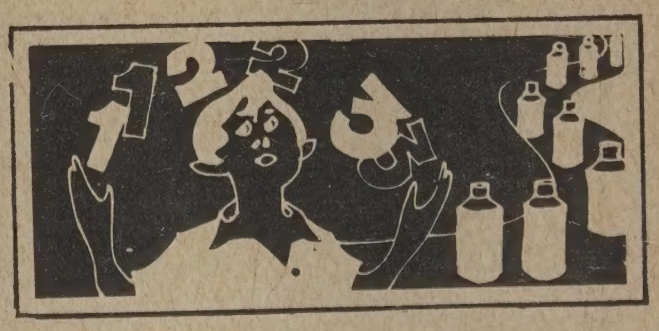


Does cattle-breeding help the rural poor?

There is no question that high-yielding cattle are necessary for maximum milk production. However, where adequate inputs are lacking, buffaloes and low-yielding cows have a role to play, even though they convert barely 6 to 11 per cent of their energy inputs into milk.

Dr. Anil Sadgopal has noted (" Does cattle-breeding help the rural poor ?", August 1977, p. 5) certain constraints in popularising cattle breeding — high cost of cross-breeds, supply of semen and processing dairy products, etc. The onus of these constraints is, however, not on the farmer but on the development agencies which are quite capable of tackling them, as ably demonstrated by the co-operative in Anand and the public sector Dairy Corporation of Punjab.

Poor farmers who cannot buy cross-bred cows have the option to upbreed their local breeds. Frozen semen can be imported by development agencies. There is also an adequate number of high potential bulls in the country from whom liquid semen can be processed. The burden of developing, marketing and processing of milk can be handled by co-operatives.

Buffaloes and goats should be given enough attention. In fact, buffaloes will continue to play a major role for quite some time. But the emphasis is on cross-bred cows purely because they have the potential for making an impact in about 15 years.

In dairy farming, feed requirements account for about 60 per cent of the production cost. To produce 25 million tons of milk (the current estimated figure) high-yielding cows would need about 30 million tons of dry fodder, buffaloes 50 million tons, and local cows 150 million tons (see table below). Under Indian conditions where straw from harvested grain crops, forage legume roughages like berseem and high-protein concentrate mixture are in use, optimum energy and protein output equivalent to that obtained in the USA can be realised with feeds consisting of 50 per cent green fodder, 25 per cent straw and 25 per cent concentrate.

D. SUNDARESAN
Director, National Dairy Research Institute
Karnal (Haryana)

Despite having 23 per cent of the world's bovine population, India's share in world milk production is a paltry 6·5 per cent. This is mainly due to low productivity.

The contention that crossbreeding is elitist in nature is refutable. Cross-bred cows which produce about 10 litres of milk per day have a distinct edge over improved Indian breeds (4 litres/day) and nondescript **desi** cows (1·5 litres/day). Cross-breds, which mature early, help save in rearing costs ; they drop their first calves within 26 to 28 months, whereas **desi** cows take up to four years. The calving interval of cross-breeds is also much less. In buffaloes such an improvement is not possible, since we have the best genetic potential in India, while in cows it is just the reverse. Improvement in buffaloes is possible through better management.

Frozen semen is readily available from many institutions and agricultural universities. The network of Intensive Cattle Development Programme and key village development schemes can provide artificial insemination facilities. Various ICAR institutes have proved that agricultural by-products are a source of cheap and readily available fodder for cattle.

And who said dairy technologists are highly paid ? Except in some private concerns, they are paid quite reasonably (equal or even less than their engineering counterparts).

If a breakthrough in agriculture was achieved by the use of high-yielding varieties of seed and better technology, a white revolution is in sight through cross-breeding, improved forage production techniques and better management.

BHUPINDER
Scientist
ICAR Research
Port Blair, S. An

The argument that " milk has no advantages over a combination of ce and pulses with regard to calories an essential amino acids " is academic. I matters related to taste, human being not rational. And if Dr. Sadgopal and Mr. D'Rozario are not for milk, why d they also reject buffaloes and goats ?

The bulk of India is not suited to rearing milch animals. On purely mon considerations, India would perhaps b better off if we completely eliminated milch animals and imported milk from countries such as Australia and New Zealand. But we have a large cattle population, and its stock must be impr Artificial insemination with frozen sem gives a higher conception rate and permits the best utilisation of quality germ plasm by preserving it for use als long after the bull is dead. Though liqu nitrogen containers have to be importe it is not necessary to buy progeny-test bull semen from abroad. The NDRI, fo instance, has progeny-tested bulls, and freezes bull semen for sale. Liquid nitrogen is a by-product of our own industry and can be utilised. Inseminati guns and disposable plastic sheaths are now being manufactured in the country Frozen bull semen is also available in ampoules ; it is possible to do without both an insemination gun and disposab sheaths.

Quality feeds and timely veterinary consultation and attention can prevent excessive expenditure on drugs. Cross-breeds admittedly require more ca The cost of this extra care is, however, more than compensated by increased m yields.

The NDRI's *Dairy Handbook* (1977), its section on buffalo management, poin out that they have to be protected from harsh weather and provided with wallow in the summer to cool off. Buffaloes are considered to be seasonal breeders and their calf mortality is very high.

As for the fear that when the " market is saturated, there is pressure to convert milk into products like butter, milk powde cheese, etc ", may I ask what will happen if buffaloes and goats are preferred over cross-breds ? Won't milk from buffaloes an goats be marketed in urban or semi-urban areas ? The bulk of the milk which is marketed now is from buffaloes.

Goats are economical to rear, mainly because they either live off someone else' land or feed on various forms of useful vegetation. Neem and even mango trees are relentlessly harvested in and around small towns and villages for feeding goats.

Generally speaking, dairying in our country is engaged in not by the rich but

Efficiency of feed conversion in Indian dairy cattle
(Full lactation)

	High-yielding cow (Karan Swiss)	Buffalo (Murrah)	Desi cows (Well fed)
Average body weight (kg)	350	480	300
Lactation yield (kg)	2,900	1,740	400
Annual yield (kg)	2,500	1,200	200
Dry matter (DM) intake/litre of milk	1·07	2·09	5·98
No. of heads to produce 25 million tons of milk per year (in millions)	10	21	125
DM intake for 25 million tons/year (in million tons)	27	52	150

80 per cent intake through high quality forage
20 per cent through concentrate mixture made mostly from by-products

mall and marginal farmers or the
ess. Better marketing and
ovement of milch animals — cows in
pinion — can help this section
er. And it is not true to say that our
sent institutional financing put the
s-bred cow beyond the reach of the
l and marginal farmer, the landless
cultural labourer, the village artisan
'. In Hoshangabad district, a bank has
n up to Rs. 4,000 per cross-bred to
andless. If the Government means
ness by what it says in its election
ifesto about dairying, then one of the
s it could help the underprivileged is by
viding loans to such sections on easier
ns, by buying milk on the basis of a
-axis policy—paying the producer a
e not just for the percentage of fat
ch milk contains but also for the
ds not fat, and allowing, wherever
sible, the underprivileged to have
ess to the common village land in yearly
tions.

r. Sadgopal and Mr. D'Rozario are
urbed that the rural elite opposed the
nges brought about when Kishore
arathi introduced cattle-breeding in
ir area. The question is : what was it
t the beneficiaries of the " semi-feudal
nomy " opposed ? Did they oppose
cross-breds or the possible rise in the
ial and economic condition of the
derprivileged ?

njustice and inequality there is in
nty but the reason for it lies in our
ial and political structure. Scientists
d technologists have provided us with
ny an answer to knotty problems and
y have every right to seek technology
ich would be appropriate to our needs.
leed it is necessary that they be
ncerned with matters social. But I wish
t they didn't confuse us with their
ories that ' intermediate ', ' appropriate',
ternative ' or ' peoples' ' technologies
n bring about drastic changes in our
cial and political structure. A technology
n at best be the **cart** and not the **horse**
bringing about social change.

SUDARSHAN KAPUR
Friends Rural Centre, Rasulia
Hoshangabad
Madhya Pradesh 461 001

It is generally found and argued that
e benefits of the transfer of improved
chnology including that of cattle-
eeding are usually siphoned off by the
ready economically and socially
owerful rural elite without touching the
ral poor. This shows the need for
odifying our rural development policies
directly benefit the poor people. The
ational policy of cross-breeding
on-descript cows and upgrading
uffaloes is being implemented under the
peration Flood programme by setting up
ne Anand pattern milk producers'
o-operatives in specified milk-sheds in
ne country in order to pass on the benefits
f cattle-breeding directly to the weaker
ections of the rural population.

An assured lucrative market for surplus
ilk and a complete package of technical
nputs for milk producers in the villages
re the basic features on which the Anand pattern of dairy development under the Operation Flood programme is being implemented in specified milk-sheds in the country. The Anand pattern of Gujarat, which the Government of India seeks to replicate, has two tiers — the village milk producers' co-operative societies at the village level, and a similar co-operative union at the district level. Both are owned, operated and controlled by the milk producers themselves. The district co-operative collects milk from the member-producers' doorsteps twice a day as well as delivers the technical inputs and services required by them. The union operates a stud farm and an artificial insemination centre, mobile veterinary clinics and a cattle feed factory. The village co-operatives provide facilities for artificial insemination, veterinary services, marketing of cattle feed and improved fodder seeds in addition to milk procurement, testing and payments. Common grazing lands (gauchars) are also set up. Farmers are informed and educated through film shows, mobile exhibitions and a monthly newsletter.

Under the fodder development programme, green fodder is now grown on previously uncultivated land such as farm boundaries and bunds. Fodder is also grown in the fallow period between two cereal crops. Therefore, cereal crops need not be substituted by fodder crops by farmers with small holdings, for whom cattle-breeding is a subsidiary avocation which depends on agricultural by-products. Nearly 70 per cent of milk producers in rural areas belong to this category.

Dairy farming on the Anand pattern, besides being highly remunerative to small farmers, has great potential for providing increased employment oppurtunities to the rural population. The largest number of employees in the milk co-operatives are unskilled, recruited from the rural areas. Even the higher cadres, including managers, are absorbed from the farming community and trained for specialised jobs.

The entire cost of these programmes when included in the milk price structure computes to only about 3 paise per kg of milk. Landless and marginal farmers are earning as much as 60 to 70 per cent and small farmers 30 to 40 per cent of their total income from the sale of milk and livestock. Already more than one million rural milk producers' families are benefiting from their membership of such co-operatives in different milk-sheds in our country.

The argument that milk has no nutritive advantage over a combination of cereals and pulses is incorrect. Milk and its products which are the only source of animal protein for 35 to 40 per cent of our population is consumed even by non-vegetarians to provide a balanced diet.

D. S. THAKUR
National Dairy Development Board
Anand

How to avoid the male gaze

Having been associated with behavioural science for quite sometime, I found the article " Gaze and mutual gaze in social encounter " (September 1977) very interesting. Among the bodily languages like gesturing with hands, " micromomentary " expressions of the face and gazing, the last is the core of non-verbal communication. One could convey several moods and tempers with the eyes alone.

It may interest some readers to know how our womenfolk have used an ingenious make-up to avert lascivious male gaze — the vermilion dot on the forehead ; it directs the male gaze to the forehead. A reference to this is found in the cultural history of Tamil Nadu. The nose ring and the black beauty spot worn on the cheek too have a similar purpose — to guide the male gaze away from direct eye-contact. In contrast, the western concepts of using lipstick, rouge and eye-shadow enhance mutual gaze in social encounters.

P. J. SURESH
74C, Harris Road
Madras 600 002

Any information on Tipu ?

Of late, particularly after the publication of the historical novel *The Sword of Tipu Sultan* by Bhagwan S. Gidwani, I have received a large number of enquiries from foreign countries about the location in India of original manuscripts, paintings, armour, relics and other memorabilia of and about Tipu Sultan. It is proposed to publish a detailed list and inventory — to begin with in English, French and Spanish — of all original sources of information on Tipu Sultan. Besides, all forts, buildings and monuments associated with Tipu Sultan will also be indicated.

May I request your readers to give me whatever information they can.

A. VADERAA
Consultant, Research and Reference Centre
(Historical Division)
E-24/25, NDSE Pt. II, New Delhi 110049

Solar hat

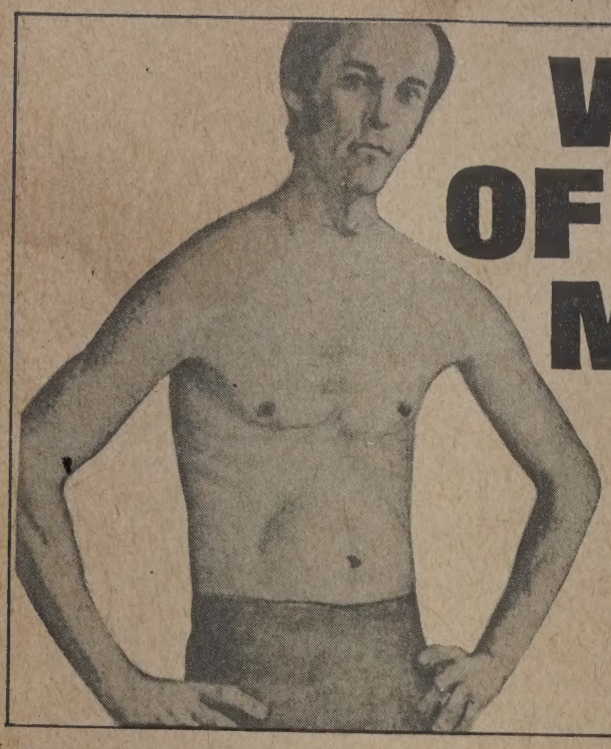
Regarding the solar-powered crop-sprayer (Ideas & Inventions, August 1977), why not experiment with powering a bicycle, the rider wearing a wheel-hat (of older days) with a solar energy collector ? The hat would also serve as a shield against the sun.

B. K. GUPTA
Varanasi

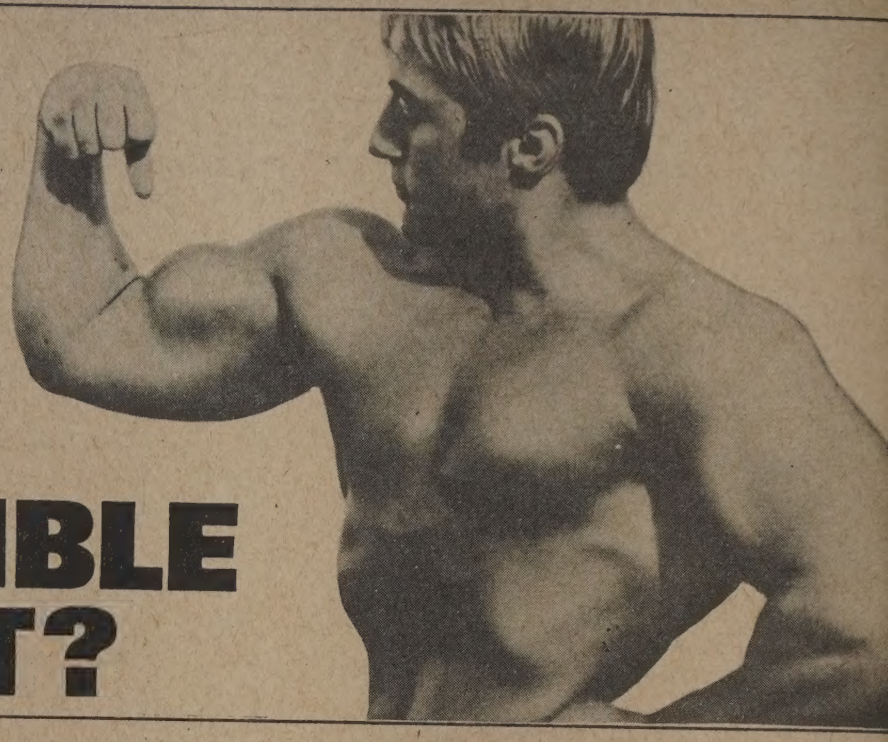
Food additive risks

The Food and Drug Administration of the United States had cyclamates for 11 years on the list of products " generally considered safe " or the " GRAS list ". Finally, it had to be banned, but only after it had caused sufficient damage. So it seems that, to really prove a substance a health hazard takes a long time and by then thousands would already be affected.

VIJAY KUMAR
KAMALA N. MENON
6-88 Temple Alwal
Bolarum (PO), Secunderabad



WHICH OF THESE MEN DO YOU RESEMBLE MOST?



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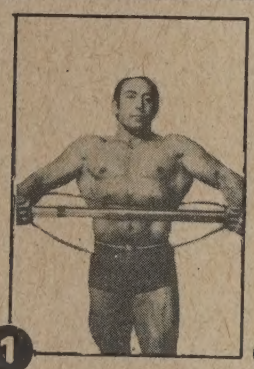
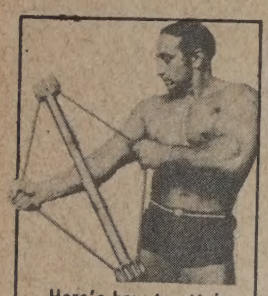
This is Len Sell, former Mr. Universe, demonstrating the simple series of 7-second Bullworker exercises. This exercise develops Deep Muscular and powerful chest.



1

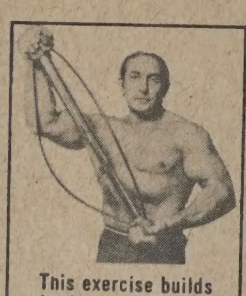
This exercise builds steel-like rippling biceps.

2



Here's how to attain that handsome athletic "V" shape.

3



This exercise builds back muscles, gives you that "man of action" look.

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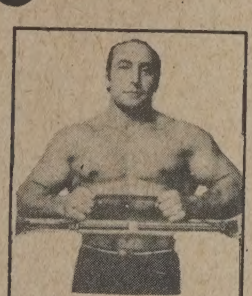
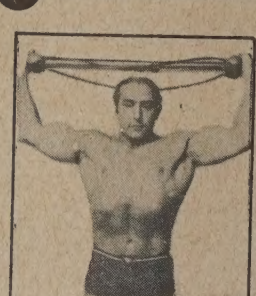


This one charges your forearms with new strength

5



Here's how you can develop muscular shoulders.

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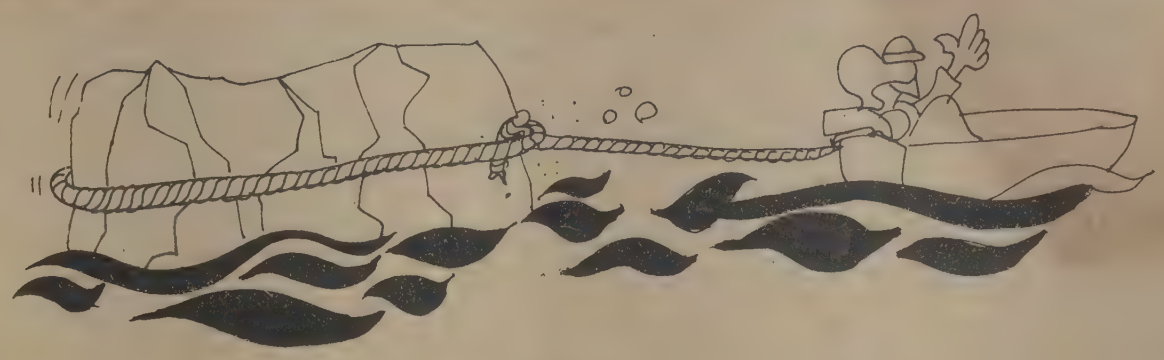
RUG TO FIGHT IRUSES

Twenty years ago, two French scientists eened a battery of animal and plant bstances for possible anti-cancer acti- y. They rejected adenine arabinoside, m a Caribbean sponge, as having little ect on cancerous cells but noticed that had antiviral activity. Then medical vestigators began exploring its possible ectiveness against various herpes seases. Last year, adenine arabinoside, ra-A for short) known in the trade as ra-A, was found to lessen pain and sten healing in immuno-suppressed tients with herpes zoster infections. lerpes zoster, or shingles, is a viral sease of the sensory nerves and brain, ten fatal). Treatment with antibiotics d been found ineffective. A drug called doxuridine looked promising until studies owed clear-cut toxicity without efficacy. chard J. Whitley and Charles A. Alford the University of Alabama, Birmingham JSA) and researchers at 14 other ntres then tried out Ara-A. In the abama studies, 28 patients who had oved positive for herpes infections were lected ; 18 were given Ara-A and 10, a acebo. Ara-A not only reduced death om 70 to 28 per cent but also the mount of permanent disability.

The findings are described in the *New ngland Journal of Medicine* (11 August 977) as a "breakthrough in systemic ntiviral therapy".



FRANCIS D'SA

AN ICE-BERG AT YOUR DOOR-STEP

For doctorate-hunters on the look out for out-of-the way research areas with, at the same time, a touch of pragmatism, ice-bergs have much to commend themselves. Scientists still know little about ice-bergs ; this was one of the things that emerged at the First International Conference on Ice-berg Utilisation held at Ames, Iowa (USA) in October. Of course, most people think ice-bergs have only a nuisance value. Remember the *Titanic*, that 'unsinkable' ship which was ripped up by an ice-berg on her maiden voyage? A whole branch of research lies in the numbers, size, lifetime, melt-rates and physics of floating ice-bergs.

Few people would have bothered about ice-bergs if some oil-rich but water-poor countries hadn't started feeling that it wouldn't be a bad thing to tow an Antarctic ice-berg to arid coasts for fresh water. A science fiction idea? Not to Saudi Arabia which gets only about 100 mm of rainfall annually and has no lakes or streams, though it does have ground-water. One problem will be how to tow an ice-berg one kilometre long, 300 metres wide and 240 metres thick and weighing 100 million tons and keep it from melting during its 8 to 12 month journey at a speed of one knot, towards northern lands. It would be necessary to protect not merely the sides but also the bottom of the ice-berg from melting in transit.

The idea is not new, but it now has the determination and money backing of Saudi Arabia's Prince Faisal behind it. Another workshop on the subject is proposed a year hence, and Prince Faisal thinks it ought to be held on an ice-breaker.

FROST ON MARS

The discovery by Viking 2's lander of what looks like frost on Mars has been described as one of the most exciting things to happen since the Viking landings last year.

Viking 2 lander is at about 43°N latitude and the Viking researchers expected the north polar cap to reach even up to the lander's feet. But though the Martian winter in its northern hemisphere began on May 31, the expected frost eluded Viking's meteorologists. Then a casual glance at a photo taken in the early afternoon of September 13 showed a number of bright white patches that very much resembled frost. It was the first time that such patches had been imaged by the lander's cameras, though hazes, fogs and possible surface frosts had been seen in photos taken from orbit.

Viking 2 photo showing patches of surface frost

The temperature on September 13 was about 174°K, about 23° to 26° too warm for carbon dioxide, the chief constituent of the Martian atmosphere, to freeze. On the other hand, the season was too dry, being about two-thirds of the way into winter, for the atmosphere to have provided much water for frost. The frost therefore seems to be a "clathrate" — a sort of dry ice/ice amalgam in which the CO_2 has become trapped in the molecular structure of the frozen water. It seems likely that the patches are actually remnants of larger frosty areas that have been sublimating away since they were formed in colder months.

One reason why meteorologists are interested in Martian weather is that it provides a simplified laboratory for understanding Earth's more complex weather mechanisms.

STERILE MALE TECHNIQUE GOES AWRY

Allowing forcibly sterilised males to run amuck among the fairer sex has been thought by scientists to be an effective method of making drastic inroads into the population — of insects at least. Now researchers of the mosquito biology unit, Mombasa, Kenya, have found that it will perhaps take more than merely sterile males to cut down their numbers.

A sizable batch of male yellow-fever mosquitoes (*Aedes aegypti*) were released experimentally by J. L. Peterson, L. P. Lounibos and Nancy Lorimer to try their luck with the damsels of the wild mosquito population in Kenya. These males had had their chromosomes tampered with in such a way that when they separated during the formation of germ cells, things didn't seem to work out right. In effect, they were sterile.

However, the team found that during the period when the sterilisation campaign should have shown maximum results, the female mosquitoes were merrily hatching fertilised eggs. The perplexed researchers deduced that the released males did not so much as look at some females, which turned out to be a sub-species of *aegypti*. More disturbing

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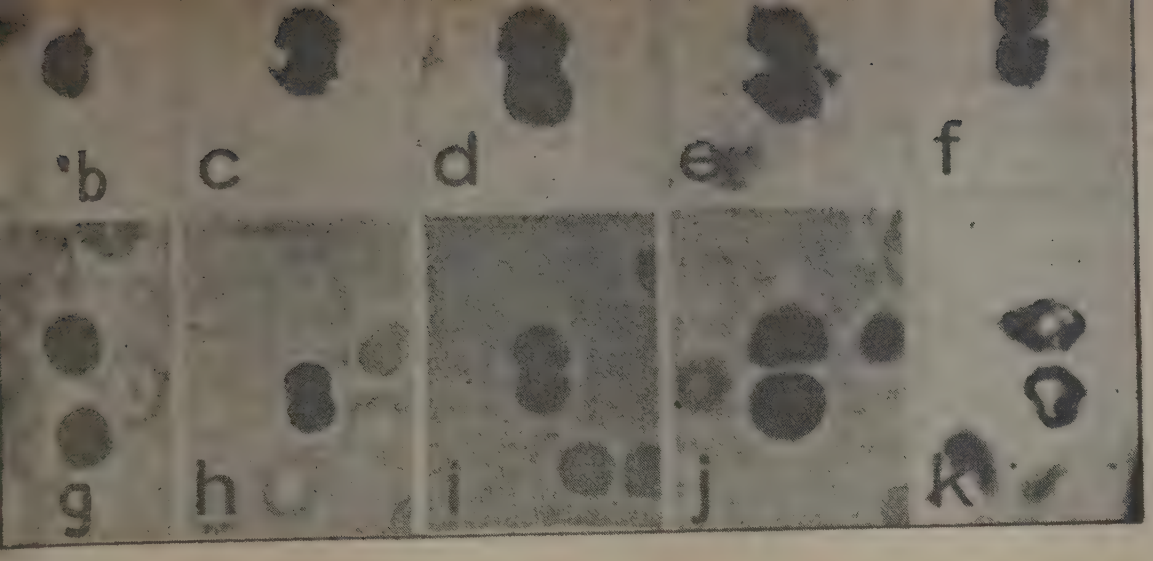


Close-up of the primitive cells (b–f, k) in various stages of cell division comparable to the "pinching off" observed in the modern, unicellular blue-green algae *Aphanocapsa* (g—j)

Two different forms, as seen through the electron microscope, of the micro-organism which may well be the oldest known form of life

OLDEST FOSSIL

In rocks, estimated at 3·5 billion years old in south-east Swaziland, have been found primitive forms of algae, some frozen in the act of cell division. The age of the rock would make these microscopic algae the oldest fossils discovered yet; the oldest previous microfossil found was dated at two billion years.

That they were indeed algae was confirmed by Elso S. Barghoorn, professor of natural history at Harvard University (USA) after a study of the chert, or silica-like rock, in which the cells had been trapped. The primitive cells were in various stages of cell division comparable to the 'pinching off' observed in the modern single-celled alga *Aphanocapsa*. The rock had lost its initial water content as it evolved over the years, but tiny drops of water remained within the crystals, preserving the floating plankton fossils for billions of years.

... THE OLDEST FORM OF LIFE?

Life, it is believed, began some three and a half to four billion years ago. It was then quite different from the living forms we see today. Broadly, existing life is classified into the "lower" forms, which includes bacteria and other such simple organisms, and the "higher" forms such as animals and plants.

A geneticist of the University of Illinois (USA), Carl Woese, has found a contemporary life-form which is different from the life-forms we know. It is a bacterium-like organism (above right) that can live only in an oxygen-free atmosphere. It would survive in the bottom of the oceans, sewage treatment plants or in the depths of hot springs like those in the Yellow Stone National Park, USA, at temperatures of 650° to 750°C.

This organism, though organised like a bacterium internally, differs in its internal chemical processes. It absorbs carbon dioxide, hydrogen and water and gives off methane. The structure of the RNA in the "archaebacterium's" ribosomes, the structures that "read" the master molecule DNA and produce the protein necessary for life, were found on analysis to be distinctly different from those of other bacteria and of plants and animals. Professor Woese speculates that this organism resembles the earliest life-forms and that all other forms of life evolved from one of these kinds as the Earth's climate and atmosphere changed.

vas the revelation that the dent which he sterile males had actually made in nosquito numbers by producing sterile ggs ironically helped the remaining eggs o do extremely well in view of the ecreased competition.

MORE LIGHT, LESS HEAT

Heat losses from conventional incandes-ent light bulbs help contribute a great nany pennies to electric suppliers' bills. n a 100-watt incandescent bulb, where ight is produced by heating the filament o white heat, about 90 per cent of the wattage is lost as heat, 80 watts in the nfrared alone.

The Massachusetts Institute of Techno-ogy (USA) has developed a new substance which if applied to the inside of a glass bulb could cut electricity consumption by as much as 60 per cent.

The reflective coating consists of a silver layer sandwiched between two ayers of titanium dioxide. This unique coating allows the visible spectrum of ight to pass through but reflects back nfrared radiation. The reflected infrared s focussed on the centrally located filament of the bulb, thus requiring less electric power to maintain the filament at an optimum operating temperature.

The coating has so far been applied only to flat-plate glass, says Prof. James D. Felske of MIT. But tests are under way to work out a durable process for sticking the coating to curved glass. Commercial production of coated bulbs in the US is expected to start by early 1979. Although potential customers will have to fork out at least four times the cost of conventional bulbs for the coated version, they are expected to be able to recoup considerably, in the final analysis, because of the drastically reduced electric consumption.

COSTING IN TERMS OF WATER

A dozen eggs cost 10,000 litres of water ! No, it's not one of those Ripley's *Believe It or Not* items. The figure emerged from the deliberations of the UN Water Conference in Argentina last March (reported in *The Ecologist*, July 1977). By the same computations, the water "cost" of a kilogram of wheat is 1,500 litres, 4,500 litres for rice, and 30,000 litres for a kilogram of prime beef. In the US, a ton of steel requires 150,000 litres of water, a ton of paper 300,000 litres, viscose rayon 800,000 litres, synthetic rubber 2,000,000 litres and a ton of streptomycin 4,000,000,000,000 litres.

If one has to *pay* for water, the Conference noted, it should be the heavy users (and polluters) through a tax or tariff. "Industry cannot forever withdraw water freely from the mainstream, nor that most households can for long remain without water meters."

EAR SAVER

Many advantages are claimed for this double-ended ear plug, designed by a Canadian company, meant to protect industrial workers from high-frequency noises. Apart from giving freedom from headache, it fits all ears and can be fitted on by the user. The "Ear-mate" plug is double-ended, making it reversible. Each end has four, pliable, concentric flanges which vary from very small to very large. To fit it in, the wearer simply inserts the end that fits best and then snips off the flanges till a comfortable fit is obtained. Made of non-allergic material, the washable plug is reusable.

The Hoshangabad Vigyan

Delhi University Science Teaching Group, Friends Rural Centre, Rasulia, and Kishore Bharati.

er the past five years, two untary agencies in the shangabad district of Madhya desh, Friends Rural Centre, sulia, and Kishore Bharati, lhanwada (via Bankhedi), have nducted what may be called a neering experiment in science ucation in village schools. The periment involved the teachers d children of 16 village schools Hoshangabad district and the phasis was on ' learning by covery '. But, it was soon covered, the phrase can remain eminar cliché, unless educational novations take the socio-nomic factors into account.

Here is the report on the shangabad Science Education ogramme jointly prepared by the

● It was examination time. Bhaiyalal sat memorising hard. The topic was, " Preparation of Oxygen ". Parrot-like, he repeated, " One, by heating glass. Two, by heating potassium permanganate. Three, by heating . . .". The possibility of glass releasing oxygen was something new for us. The boy insisted, " Guruji told us that glass, when heated well, gives off oxygen." His class notes, duly corrected by the teacher, confirmed his statement. We were puzzled. Going through his textbook, the mystery was solved. It said that oxygen can be prepared by heating the oxide of lead (*seesa*). The teacher applied his ingenuity to interpret 'सीसा' as 'शीशा'. From *sheesha* to *kanch* (glass) was a short step. The 'oxide' fell on the wayside.

● Takhat Singh was a brilliant student. The teacher liked to present him as an example to any visitor. One day we visited Takhat's school. With his teacher looking proudly on, he rattled off the names of different parts of a flower: calyx, corolla, anthers, stamens, gynaecium, carpels, . . . onwards to nucellus (Hindi equivalents, of course). However, when a flower was placed before him, he was stumped.

● Some children sat drawing circles of different diameters with the help of their compasses. The teacher had trained them well. A casual question was posed by one of us, " Can you draw a circle of 4 feet diameter?" The whole class looked dumbfounded. School had taught them to draw circles using only a compass. A compass had its limits. " If you had to dig a well, 4 feet in diameter, how would you begin?" we prompted. The young faces lit up. " That's easy—using a peg and a string!" They confidently set about demonstrating their skill.

The incidents described above were some of the first-hand observations made by us in some village schools in Madhya Pradesh. They illustrate a serious malady in the teaching of science in rural schools. (Urban schools fare, perhaps, just a bit better!) In our perspective of rural development, a wide-ranging attack on such significant gaps between expectations and reality in education occupies a prominent place. Why does a child have to memorise a whole range of disconnected and irrelevant facts in the name of science? These facts often

make little sense to the teachers themselves and are seldom remembered beyond the examination. What use is terminology which conveys nothing beyond imposing words? What use is education that builds up barriers between classroom learning and real life experiences? What use is information if it cannot be applied to solving practical problems?

We were faced with some stark facts. First, knowledge is growing exponentially. No one can be expected to know or retain any significant fraction of it. Second, it is generally accepted that 60 to 70 per cent of village children do not enter the school system or drop out at an early age. Of those who do manage to continue, a mere one-fifth enter high school in rural areas. Our present education is mainly designed for these privileged few. This, to us, was a contradiction. The focus of education, we felt, should be to prepare the vast majority which drops out midway for facing the tough school of earning a livelihood. Educational objectives, thus, need to be re-defined in this perspective. Science education must aim at developing skills and attitudes which enable students to learn directly from their environment and experiences.

Such ideas were concretised in a proposal we presented to the Director of Public Instruction at Bhopal in February 1972. We were apprehensive. We had no *locus standi* in the field of school education. The pre-eminence of professional and resourceful organisations like the National Council of Educational Research and Training (NCERT), State Institutes of Science Education and State Institutes of Education engaged in the task of improving science teaching was fully recognised by us. There was a plus factor, however. We had sought and received the support of Mr. B. G. Pitre and Mr. C. K. Dikshit of the All India Science Teachers' Association (AISTA) Physics Study Group and Prof. Yash Pal and Mr. V. G. Kulkarni of the Tata Institute of Fundamental Research, Bombay. They had conducted pioneering trials in introducing the discovery approach to the learning of physics in a few Public and Municipal schools. Building upon their experiences, we intended to test the feasibility of the discovery approach under village conditions. We would also cover all science subjects, utilising the environment as a source of learning.

Children, our proposal stated, should learn science by performing experiments with their own hands, recording their observations, and deriving independent conclusions through discussions with their classmates and teachers. They should be encouraged to ask questions, critically examine evidence and analyse new situations that might arise. Rote learning of facts and definitions should be ruled out. Storage of information must not be the sole criterion of learning. The teacher would cease to be the fountainhead of all knowledge. His role, instead, would be that of a guide and helper. This meant that traditional barriers of syllabus, teaching methods, textbooks, teacher-student relationships and school administration would have to be broken. The curriculum would emerge from the day-to-day experiences of the teachers and children, not from the scholarly expectations of city-based experts. The demands of the examination system would also have to undergo a radical change in keeping with the new objectives. We sought freedom to do all this.

The State Government gave us permission to experiment in 16 middle schools, nine around Friends Rural Centre in Hoshangabad Block, and seven around Kishore Bharati Bankheri Block. The schools and teachers were selected randomly ensure representative conditions. State and the District educa authorities assured full co-operat The continuous backing and unh tating freedom given by the Gov ment of Madhya Pradesh has not been the cornerstone of the gramme, but at times also its insp tion. This quality and extent of Government support to a volunt group for experimenting with sch education within its own structur perhaps without precedence in country.

And, thus, the experiment beg

Encounters with the teachers

The morning 25 May 1972 saw an unsure fac facing an apprehensive group of teachers. The first Orientation Co had begun. There was no inaugu tion, no fanfare. The District Edu tion Officer (DEO) had warned that most of the teachers had stud

Encounters with the teachers. This photo series shows participants in the 21-day course. From the classroom (above), the meetings later shifted to the open air

only up to high school and had li or no science background. The ol ones joined service after middle sch Only four or five were graduates, in science.

The ice was broken by a questi "What do you find lacking in present education system?" A liv dialogue was sparked off. It s petered out into an uneasy sile with the arrival of the DEO. After awkward pause, a teacher stood and asked reverently, "If Sa'ab not be offended, may I make a hum submission?" "Yes, yes", the D encouraged. "Could we not recre the mood of the assembly wh existed before DEO Sa'ab joined us the teacher dared. Despite his app and the DEO's encouragement, openness of the earlier discuss could not be re-established. That our first taste of the hierarchi

structure of the Education Department which stifles communication and feedback from the grassroots to the planners.

Only a year later, however, the same teachers took the visit of the State Education Minister in their stride. His arrival caused only a minor flutter. The teachers continued to perform the experiments even when the Minister stopped at their tables to observe them. Today these teachers can participate in uninhibited discussions with senior administrators, educationists, scientists and NCERT representatives.

The faculty had created an informal and open atmosphere from the very beginning. Small things like serving food and eating in the same *pangat* had their own significance. When teachers were reluctant to try out new experiments which appeared too simple, Prof. Yash Pal's " Yar, kar ke to dekho " with a friendly pat on the back made all the difference. The faculty even shocked many of the teachers by announcing that they were free to smoke bidis in the hall itself.

red because we cut the twig. I have seen apples turn brown after cutting."

Although the question appeared trivial to us, it could not be ignored. Such questions form the backbone of the discovery approach, providing links for further experimentation. A heated debate followed. It was decided to modify the experiment by including a second twig placed in plain water. The concept of using ' controls ' was born.

The teachers were by now thoroughly engrossed in the spirit of enquiry. " What would happen if we use blue ink? " asked one. All faces turned to the faculty biologist. He shrugged, " I do not know ". The teachers were flabbergasted. They asked in disbelief, " How did you get your PhD if you do not know such simple things? " It was a jolt to their value system. To them a PhD signified the end-point of all knowledge. Here was a chance to illustrate the open-endedness of scientific enquiry. The experiment was repeated with different inks. The selective absorption of different chemicals by plants was strikingly demonstrated. The full implications of the discovery approach only then dawned upon the teachers. They began to realise that they, too, would often be forced into such tight spots when they would have to admit, " I do not know the answer. Let us find out." It was a negation of the traditional pre-eminence of the teacher. It has been a long battle. The ' I do not know ' philosophy is only now slowly sinking in.

Throughout the 21-day Course, the teachers had free access to kit materials and books. For the first time in their experience of such courses (some had been through many), they were actually doing experiments. They were perplexed that these experiments could be performed with simple items like thread, balloons, rubber bands, paper clips, buttons and *kulhads* (earthen cups).

The basic issues of the discovery approach soon began surfacing. For example, discussing plant life in a biology session, a teacher-farmer raised a question, " How do fertilisers in soil reach the leaves? " At once, an experiment was planned. A twig was cut and placed in red ink solution. Half an hour later, the leaf veins turned red. The conclusion was obvious. But one teacher was sceptical, " How can we be sure? Perhaps the veins turned

Even simple exercises, for instance, of measuring lengths, had many surprises in store for us. The teachers were asked to measure the length of a table. "*Arre!* This is child's play ", they said. " Let us do something more serious ". We persisted. One by one, reluctantly, they walked up to the table, metre sticks in hand. Their confidence soon paled to dismay. Some had problems in reading the scale, others with decimals, while a few could not even distinguish the centimetres from the inches. Sheepishly they submitted to the training in measurements. Everyone was asked to measure the length of the blackboard: 200·8 cm, 198·7 cm, 200·5 cm, 199·2 cm, 201·2 cm . . . ran the list. "Why this variation? " was the question. Maybe they had made mistakes. They measured again, more cautiously. They were visibly disturbed by the persistence of variation. For them the sanctity of science lay in its exactness. The weighings and measurements of shopkeepers, too, showed such variations, but they put that down to cheating. A cosmic ray physicist came forward to relate his experience of similar variations in cosmic ray measurements, even with 'phoren' equipment. That day a new word 'घटबढ' (*ghat-bad*), literally decrease-increase, was added to their scientific vocabulary.

OF THIEVES, PACKING CASES AND AMALGAMATED FUNDS

It had become a familiar story. The teachers were once again complaining of the sorry state of their kit. It lay scattered, open to attack from rats, thieves, wind, rain and dust. " No extra almirahs can be given for storing the kit ", the teachers had been informed by the authorities. We had suggested packing cases as an alternative. The teachers were cynical. The kit cannot fit into packing cases, they insisted. We showed them how to do it by building shelves, hooks, slots and covers with hinges and latches. Such cases with fittings could be assembled by the children themselves at a cost of about Rs. 15 per school. " Where is this money to come from? " asked the teachers at a monthly meeting. The DEO reminded them of the Amalgamated Fund which is built up from small annual contributions from the children and is meant for such miscellaneous school expenses. Nothing happened.

At the beginning of the next academic year, we raised the issue of the packing cases again. By now, we had some fresh information. An Assistant District Inspector of Schools had quite enthusiastically informed us that he could supply all the cases the schools needed. Consignments of chalk for the schools came to his office packed in such cases. The packing cases, after emptying, were usually ' gifted ' away. He had assured us that these would be reserved for the schools to build kit-cases.

One year passed. No packing cases had gone to the schools. In many schools the kit continues to lie scattered, open to attack from rats, thieves. . . . .

'4 FEET 8 INCHES = 4·8 FEET'

On a rainy August day in 1972, within barely six weeks of the beginning of the Programme, a follow-up visit to one of the schools brought out a situation for which we were least prepared. The children were found engrossed in measuring the heights of one another with the metre sticks provided in the kit. The heights were being recorded on the black board by one of the students in order to prepare a histogram. One boy was 4′8″ tall. The student at the black board wrote it down as '4 feet 8 inches'. Suddenly, a sharp reaction from the teacher sent a shiver down his spine: "Why don't you write this in decimals?" The student just stared blankly. Came a further prompt, "Write 4·8 feet". The student quietly complied. We just could not believe this. The alarm had been sounded. All follow-up workers were asked to check on the children's and teachers' understanding of decimals. In a majority of cases, the first experience was confirmed.

In the next month's follow-up meeting with the teachers, the issue was raised. The teachers were adamant. According to them, the children understood decimals as they were supposed to have mastered these in primary classes. The question of the teachers' ignorance, of course, did not arise. The teachers' sensitivity on this issue made remedial measures impossible. It was more a psychological problem than an academic one. It had to be tackled on that plane.

We had to wait until the next monthly meeting. An experiment was planned. Each teacher, quietly and without any warning, was given a scale, each with a different number of divisions per inch. When asked to measure the length of their books, they reported results like 10·2″ with a scale of 4 divisions per inch, and 8·11″ (eight point *eleven* inches) with a scale having 12 divisions per inch. The game was now up.

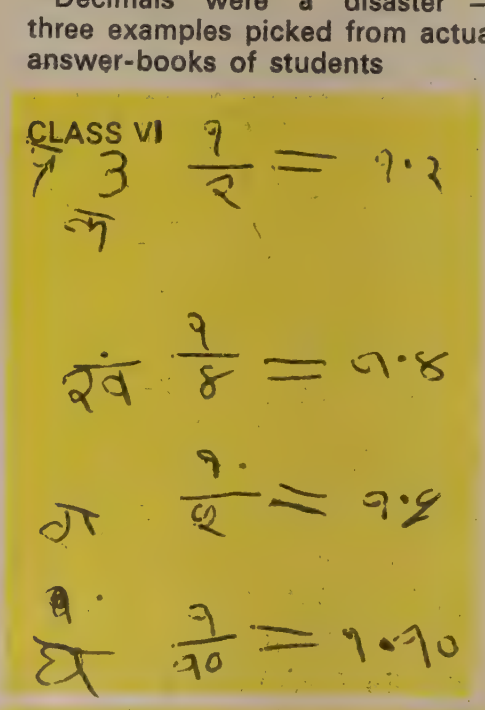
The need for a remedial course in decimals had been established. The Resource Group members put their heads together. A trial draft was ready by the 1974 Orientation Course. In this novel approach, the children were expected to make an abacus of their own and use it to understand the significance of place value and, hence, decimals. Two research students took up the challenge of designing an appropriate abacus. What came out of this effort has now come to be known as *GANAK*. It is an assembly of six straight wires fixed vertically and equidistant on a wooden platform. The background is made of stiff rectangular paper pasted with strips of coloured paper and fitted with a small triangular paper rider to mark a decimal point (see figure above). The length of the vertical wires is adjusted such that they accommodate exactly nine beads and no more. To add the tenth bead, one has to remove all the beads and replace them with one bead on the next wire to the left. This simple device enables the students to discover for themselves the basic rules of addition and subtraction in decimals as well as conversion to fractions. The topic is introduced to the children with an interesting story of the beginning of counting based on our ten fingers. The abacus activity is backed up by concrete experiments on length, area, volume and weights.

Some of the seniormost State and District level education officials who came to see the Orientation Course witnessed the teachers being trained in this new approach. They immediately wanted to know the reasons for spending so much energy and time on decimals at the middle school level. Soon a group of about 20 children studying in mid school was gathered from the neighbo ing villages. An impromptu test p duced irrefutable evidence (see pho stats of tests below). The remedial act in decimals through abacus and ot experiments is now an integral part the science programme in the 16 mid schools.

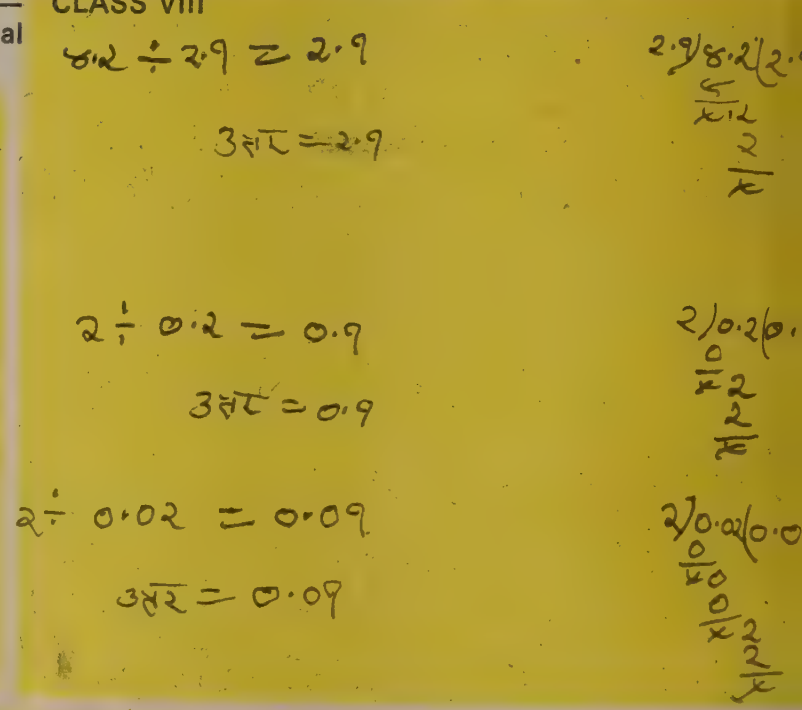
The process of convincing the teach community and the education offici about the wide gap between the expec tions and the reality in the case decimals and of evolving an innovati has been one of the most exciting batt of the Science Education Programme.

"Decimals were a disaster"— three examples picked from actual answer-books of students

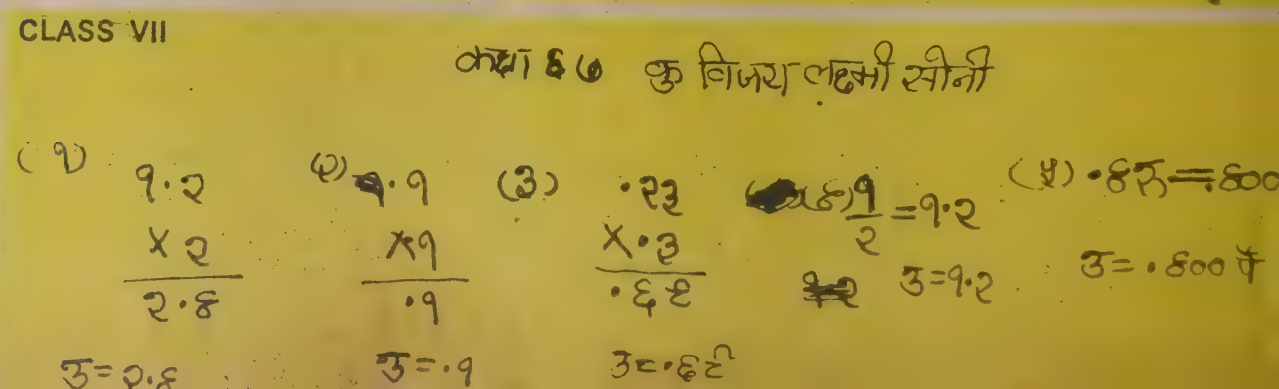
CLASS VI

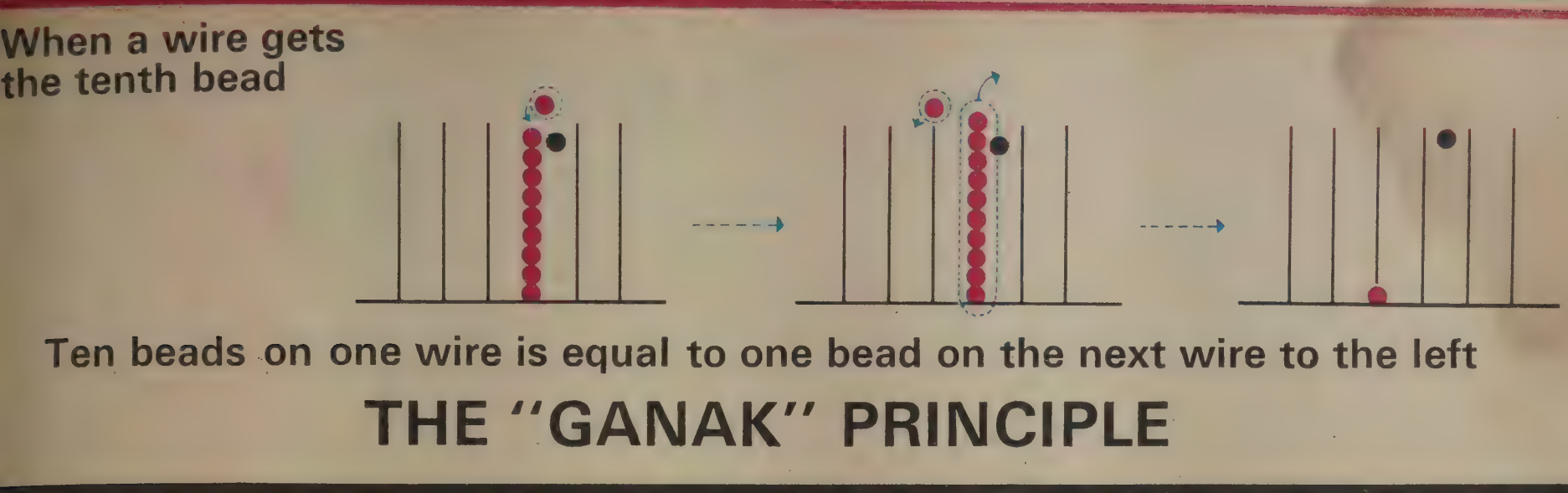


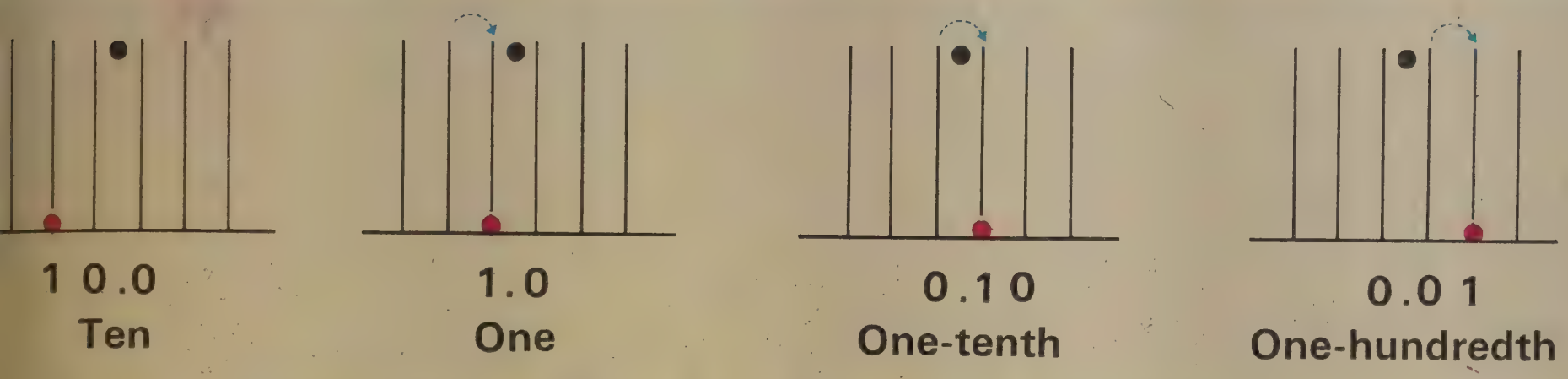
CLASS VIII

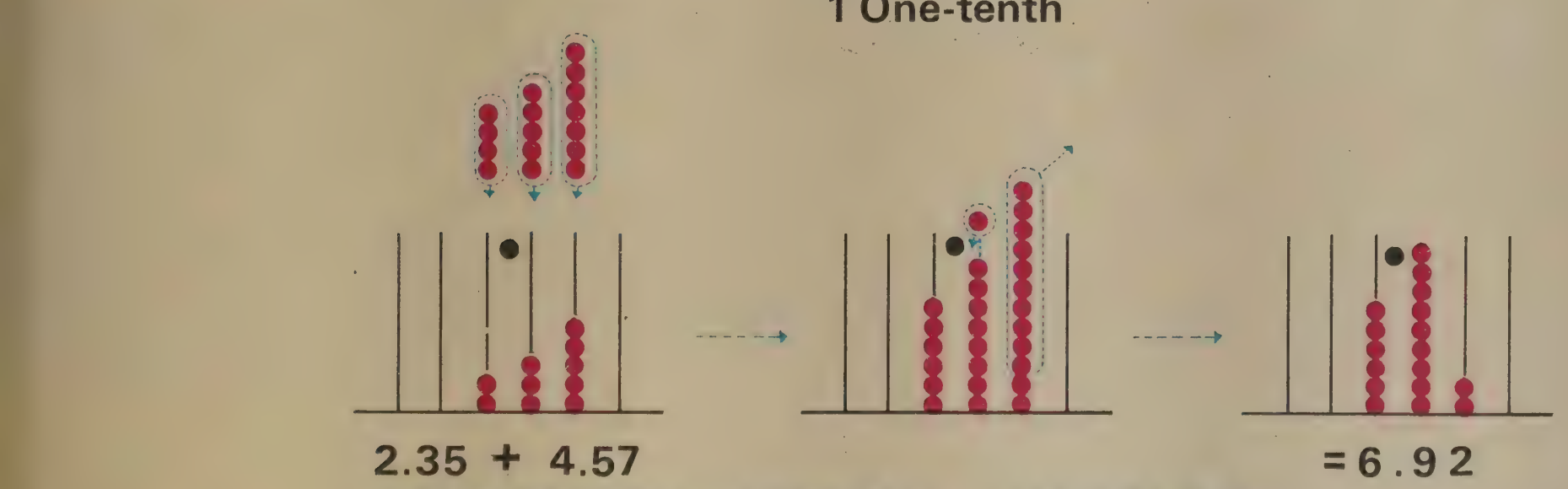


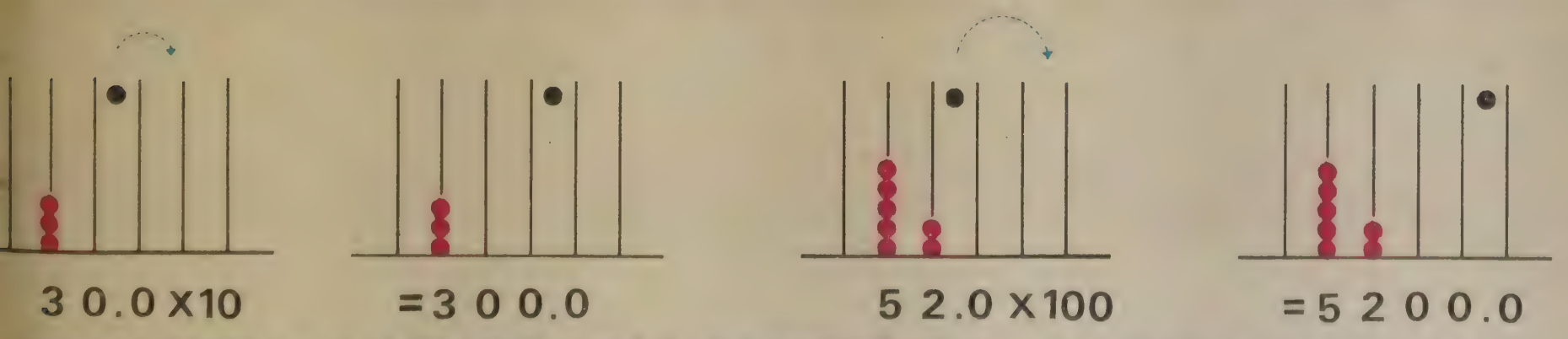
CLASS VII











The programme goes to the schools

The teachers at nce put their training to practice in heir schools. They were no longer cturing. Children were split into groups of four to five to do experiments. Later on, *Paribhraman* (field trips) was introduced as an integral part of the curriculum. Special emphasis was placed on the role of follow-up visits by faculty members to the classrooms — not for inspection but for assistance, assessment and collection of feedback. Initially, the teachers tended to hand over the class to us. We had to insist on our observer status. At times, our strong

impulse to interfere had to be stifled. This was particularly difficult in situations of inept handling by the teachers, in moments of great excitement or when a teacher reverted to lecturing. Sitting with the children on the floor, we would go through their workbooks, assist in experiments, jot down our observations and collect criticisms and suggestions from them. We sometimes put new ideas and "brainwaves" to test. When chance permitted, we would step aside for a brief discussion with the teacher. Informal after-class sessions with the children and teachers were often more revealing and helped in sorting out knotty problems.

Intensive school visits and teachers' monthly meetings soon destroyed many of our romantic notions. We often found the sixth, seventh and eighth classes running simultaneously in one room, with the primary classes on the verandah, religiously chanting their lessons. Sometimes, a single teacher would handle more than one class at a time. 'No classes' was a frequent phenomenon (see "My Village School Zodiac", p. 20). Kit material was often left uncleaned and flung around in disarray. Advance preparations for the day's experiments were uncommon. Record books of the children were infrequently checked. The kit was misused. Plastic buckets, scissors, blades and thread found their way to private homes. Influential village leaders took the liberty of calling for plastic dishes, mugs and tumblers for their wedding feasts. These sometimes never came back. Interesting items like magnets, lenses and torch bulbs were irresistible to the children and were promptly pinched. Lack of cupboards posed a serious storage problem, leading to alarming attrition rates (see box on p. 15).

We had not expected very high academic standards, but what startled us most was the rock-bottom level of children's development. Minimum capabilities of written expression, comprehension and mathematics, which they should have acquir primary school, were glaringly ing. Children could not even wr simple Hindi an event which had observed. Elementary instru in the workbook were not co hended. Some could not even Those who could, failed to instructions to actions. They had trained only to memorise. Pri numeracy skills were not fully loped. Basic concepts like place and one-to-one correspondence not been understood. A child could count up to 500 was ba when asked to write 501. Deci were a disaster (see box on p. All this adversely affected children's capability to do and di science experiments.

Line diagrams conveyed pre little to them. They could not, instance, associate a two-dimensi diagram of a beaker with an a one. Their ability to draw objec front of them was limited. Dra from imagination was out of quest

THE UNIVERSAL CUBE

The markets of Hoshangabad, Piparia, Itarsi, Bhopal, Delhi and Bombay had been ransacked. Several workshops said, "It is impossible, at your cost." We were looking for one-gram weights for experiments on springs and balances. Each school needed approximately 100 such weights. Where were we to find them? It suddenly struck us, the answer was in our kit. There were one cubic centimetre plastic cubes in the kit which had been included in the first place for volume experiments (shown in the photographs below). These cubes were slightly heavier than water and weighed one gram each to an accuracy of 10 per cent. Expensive weights were no longer needed.

It later occurred to us that, since each surface of the cube was a unit area and each edge a unit length, they were suitable for experiments on the measure of area, length and perimeter. When chapter 'Chance and Probability' developed, the cubes served as dice white dots painted on their faces. one of the monthly meetings, a tea narrated how he had used the cube form three-dimensional histograms w children experienced difficulties in plot them on paper.

Proportions meant nothing. Common ymbols like arrows and simple techniques of showing depth or distance n drawing were totally alien. The ignificance of using colours in drawngs and maps was lost on them. This an largely be attributed to their nonexposure to standard communication naterial like magazines and books normally accessible to an urban child. Another major factor is the bsence of drawing activity in primary chool. Colours, crayons and paper re a rare phenomenon in their nvironment.

The teachers, too, had their problems. Harassment, transfers, attachments, administrative and survey vork, *nasbandi* campaigns, low salaries nd bossism of local politicians are nly some of the factors which take a eacher's mind off teaching. The eaching profession has lost its legendary prestige. Working under such dverse physical, social and economic conditions, is it any wonder that eaching takes a back seat? The discovery approach has failed to make ny dent in these structural barriers. Unmotivated teachers remain unnspired.

But there is a silver lining. About alf the teachers who already had a igh level of motivation exploited the venues opened up by the discovery pproach. This, and the unbounded nthusiasm of the children, provides he rationale for such innovative fforts. There are teachers who have uccessfully inspired children to take omplete responsibility for the mangement of the kit. In several instanes, children and teachers have athered after class hours to observe he night skies. Some children have hown initiative in going beyond class xperiments by designing their own ttle gadgets like projectors, electric notors and bells, torches and musical oys from whatever materials they ould lay their hands on. There are chools where children organise themelves to continue experiments during he teacher's absence. During field rips, the natural curiosity of children seen at its best. Diving into rivers, lodding through mud, climbing trees nd daringly probing burrows, they ome back with rare specimens of nimals, plants, rocks, insects, eggs nd nests. On holidays and Sundays, any frequently walk several kilonetres to come to us with their ueries, insisting upon being given aterial to perform experiments and eking appreciation for their creative fforts.

It has been our repeated experience at a crucial factor in the proper orking of any school is the concern shown by the village people. A striking example is that of a teacher who hardly taught for three years in a village where people were disinterested. On being transferred to a village where people were concerned about the education of their children, his true potential came to the fore, so much so that he has proved to be one of the most enterprising teachers in the programme.

TEXTBOOK vs. WORKBOOK

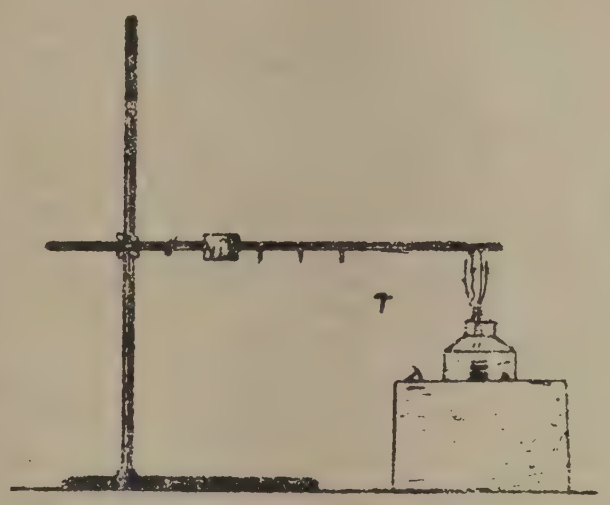
A standard seventh class textbook widely used in schools, gives the following experiment:

CONDUCTION OF HEAT

The transfer of heat between two objects in contact or between different parts of a single object is called conduction.

The conduction of heat can be understood properly from the following experiment:

Fix the end of a piece of thick copper wire to a stand. Stick small iron nails to this wire with the help of wax. Now heat the other end of the wire with a spirit lamp. You will observe that the nails start falling off one by one from the heated end. This clearly demonstrates that heat is slowly conducted from one end of the wire to the other. Heat



conduction can be explained on the basis of the molecular structure of matter.

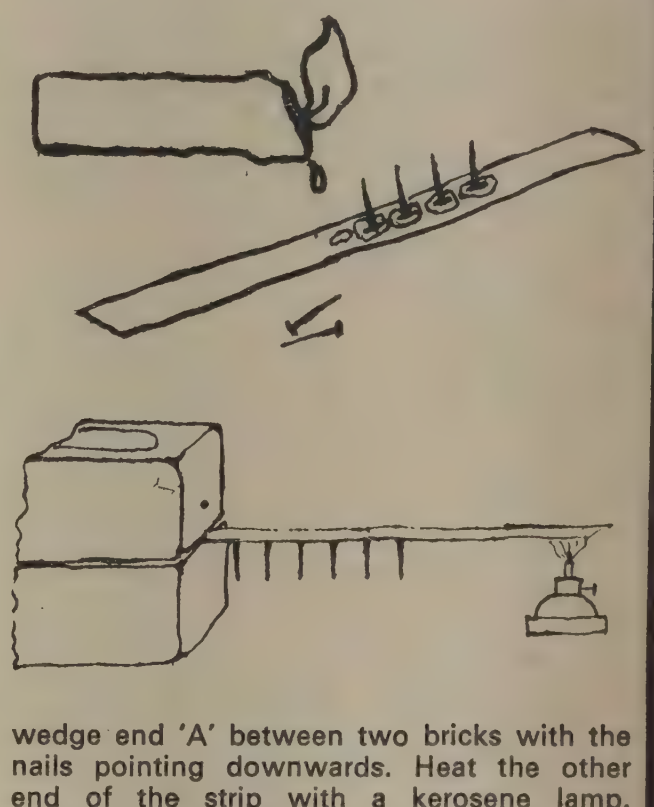
On receiving heat energy, the molecules near the heated end start oscillating with a speed greater than that of other molecules in the vicinity. These molecules collide with their neighbours, causing them also to start oscillating fast. The process continues and heat energy is thus conducted continuously from one layer to the next.

Dear Reader, having been given the definition of conduction, sketchy instructions to perform the experiment, the result, the inference and the sophisticated explanation using kinetic molecular theory, would you now proceed to perform this experiment? You will need a stand costing only about Rs. 13, a spirit lamp costing Rs. 2·50, a thick copper wire (how much will it cost and where is it available?) and a few nails. Wish you best of luck trying to stick nails with wax on a thick round copper wire!

Consider the same experiment from our workbook as performed in the schools:

TRANSFER OF HEAT

Take an iron strip approximately 15 cm long. Using a lighted candle, put a drop of molten wax on the strip about 4 cm from the end marked 'A'. Stick a 1·5 cm long nail in the wax as it cools. In this way, fix five more nails on the strip at 1 cm intervals. Now



wedge end 'A' between two bricks with the nails pointing downwards. Heat the other end of the strip with a kerosene lamp. Record the time at which you started heating, in a Table. Also, record the time when each nail falls.

Why did the nails fall?

Why didn't all the nails fall together?

Plot a graph between the time when each nail falls and its distance from the heated end.

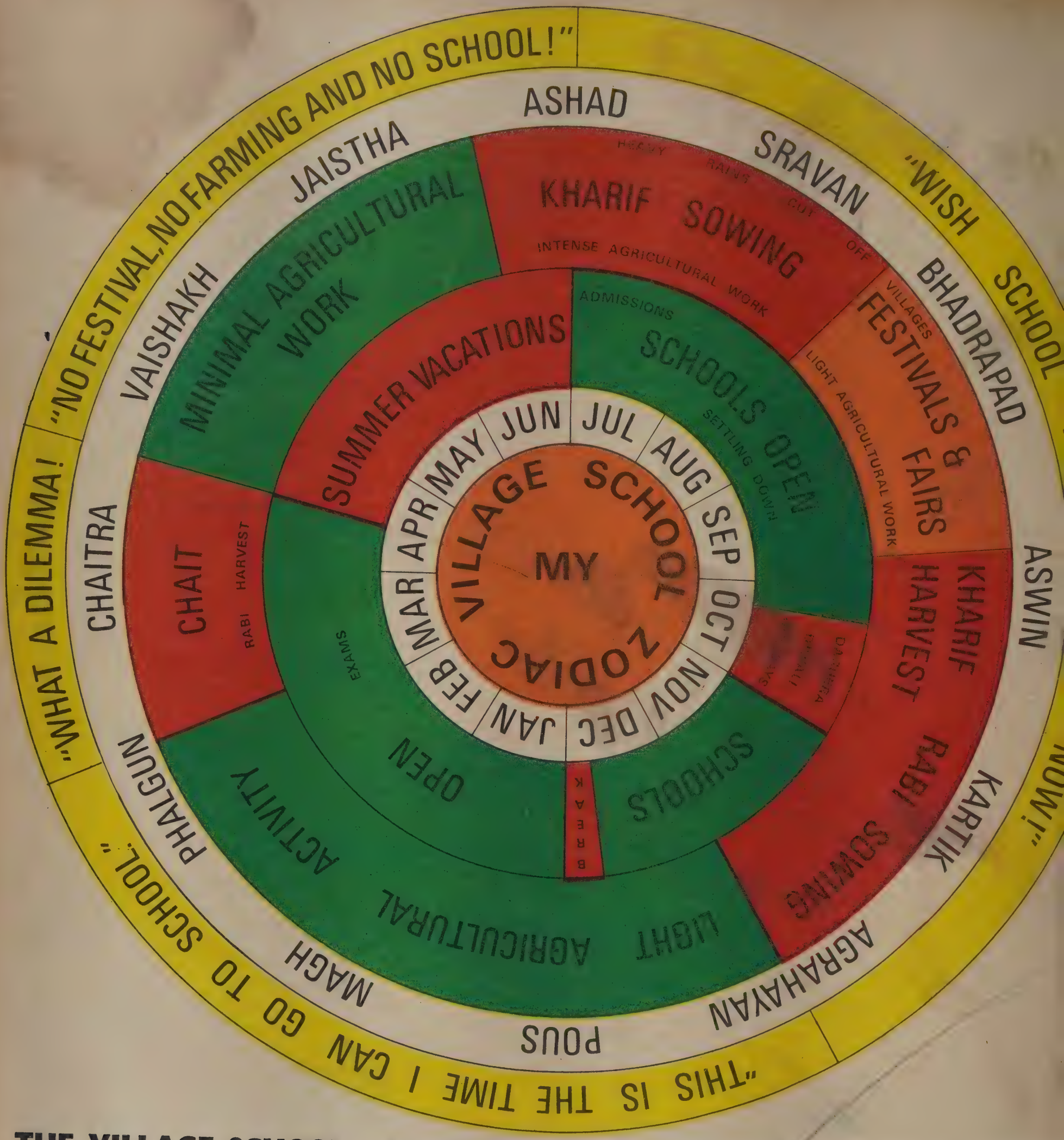
Is the graph a straight line?

On the basis of this experiment, write your views on the transfer of heat in metals (solids).

Dear Reader, perform the experiment and discover heat conduction for yourself. The bricks should cost you nothing, the nails, not more than five paise and the kerosene lamp, a rupee. The iron strip is simply a piece of a packing strip.

A workbook with a difference

The basic tenets of the workbook were defined early in the programme. Its text would make experiments inevitable. It would give instructions for performing these experiments, followed by leading questions to initiate discussions. No definitions, no facts and no ready-made answers would be given. Adherence



THE VILLAGE SCHOOL ZODIAC

It was mid-July of 1973. A young physicist from Delhi University arrived at Kishore Bharati bubbling with enthusiasm. This was his first follow-up visit. The very next morning, the villagers found him slowly cycling towards a village 10 km away. He had spent several hours the previous night designing bright new experiments to try out with the children. But when he finally got to the school, he found the Head Master laboriously filling up a pile of registers, and a few of the teachers sitting around in a gossip session. There was no sign of children. He was informed that the teachers were busy with the admission *ka chakkar* and with collecting information asked for by the District authorities. The few children who did turn up by default had been given *chhutti*. The young physicist thoughtfully cycled back, disappointed but hopeful that this *chhutti* mood would not be a pattern. His hopes were soon belied. Next day in a different school, he found even the teachers missing. It was the weekly market day.

The subsequent months revealed more and more reasons for the dismally irregular functioning of the schools. These included paddy transplanting, leaking school roofs, inaccessibility due to villages being cut off by seasonal rivers, local festivals and village fairs. At times the teachers were absent, having gone on leave or on administrative work. Once a month they walked t village 2 or 3 km away to collect th monthly salaries and preferred to cal a day. On another occasion, the De University physicist cycled to a sch 14 km away, struggling through kn deep mud and often carrying the bicy up in his hands, and found the sch locked. Enquiries revealed that t whole village had been invited to t *rasoi* (feast after the death of a fam member) in the house of the villa Patel.

The second member of the De University team stationed at Rasu had similar experiences. Both the tea members returned to Delhi Universi by the end of October with first-ha experiences of the contradictions b tween the life of the village and t

"WE TEACH FOR ONLY 70 DAYS A YEAR"

An NCERT bulletin *The Curriculum for the Ten-year School — a Framework* released in 1975, states, "There should be a minimum of 240 working days in a year, out of which 220 days are for instruction and 20 days for school camps and community services, etc". A senior State education officer privately informed us that the syllabus is, in fact, planned for only 150 to 160 working days. A headmaster of one of the better-managed schools in Hoshangabad district gave us the following estimate:

	DAYS	TOTAL
Total number of days per year		365
Summer vacations	75	
Dashehra - Diwali vacations + Winter Break	30	
Authorised holidays	18	
Sundays	37	
Total official non-working days		160
Official working days		205
Market days	18	
Inaccessible due to rains	25	
Admissions	7	
Festivals & Fairs	15	
Village Social Occasions*	10	
Agricultural work	10	
Preparations for exams, invigilation and evaluation duties	30	
Teachers' casual leave	13	
Pay days	8	
French leave	5	
Total unofficial non-instructional days		141
NUMBER OF DAYS WE TEACH		64

*Wedding and death feasts and *kathas* arranged by the Patel and other elite when attendance is compulsory.

school system. The schools are expected to function when the children are busy assisting their parents in the fields. Somehow the school experts seem to be totally oblivious of the pressures of the sowing and harvesting seasons in the life of the village. The annual examinations coincide with the rabi harvest period. While the weekly market day, a major social and economic event, is ignored, the legacy of the Sunday holiday persists from the British Raj. The summer months, when the children are relatively free, find the schools closed for vacations. No one who matters in the education system of the country seems to be prepared to explain the reasons for this major disharmony affecting the lives of the millions of village children.

to these principles is crucial to the success of the 'discovery' approach. Textbooks in use today pay only lip service to the method of learning through experiments. Phrases such as "Look and discover", "What did you observe?", "What do you conclude?" and "Learn by doing" are often used in them. However, there is little scope for either experimentation or for drawing independent inferences. No time-lag is given between the two processes (see box on p. 19).

It is our contention that no appropriate workbook or kit can be evolved without direct interaction with the teachers and children under school conditions. We have innumerable examples where such interactions have led to major changes in the material, which otherwise we would never have thought of (see boxes on pages 16, 18). Most textbooks now in use have been prepared without the benefit of such interaction. (In fact, even the machinery for collecting and using feedback is either unutilised or not developed at all.) The result of this lack of interaction is clearly evident in a set of attractive primary school textbooks professing to base science on experimentation. Children are asked to collect pictures of rockets and satellites from newspapers and magazines as part of a home assignment. Such printed material is almost always unavailable even among the affluent in the villages. The poor cannot even acquire scraps of waste paper for rough work. The demand for ice in one experiment and for a globe in another are further examples. Perhaps the most ironical example is the sentence meant for children in Madhya Pradesh: "Your friends living near the sea must be familiar with high and low tides!"

Our workbook has thus evolved during the past five years through this process of continuous trial and error under field conditions. Yet we consider the totally revised version in use today as only tentative. It is bound to undergo further changes in order to reflect more closely the true life situation. Meanwhile, the present draft, approved by the Madhya Pradesh Government, is being published by the M.P. Text Book Corporation.

Thorns and Test-tubes — The kit

"We are a poor nation; we cannot supply kits for experiments. The discovery approach is a luxury only affluent nations can afford." How often such apologies are heard. These derive from the myth that science experiments can be done only with fancy glassware, costly chemicals and sophisticated physical apparatus. Our experience has been totally to the contrary. The use of sophisticated equipment is not merely unnecessary but, in some cases, actually undesirable. It aids in the mystification of science, removing it farther from the day-to-day realities of life.

We designed our kit to suit the workbook. It is not a demonstration kit. For an average school comprising of 120 students in three classes, the kit originally cost slightly more than Rs. 1,000. In its present form it costs about Rs. 800. The replacement cost (of consumable and breakable items) is about Rs. 150 per year per school, averaging Rs. 1·25 per student per year. Lower costs have been achieved by making some items more versatile and by replacing expensive materials with cheaper, locally available substitutes (see box on p. 18). For example, dissection needles have been withdrawn in favour of zero-cost *babul ka kanta* (acacia spine). Costly iron stands have been made redundant by tying burettes to a pillar or the leg of an upturned table. Burettes themselves have given way to jet-siphons drawn from a bucket for water-clock experiments. Volumetric titrations are carried out using droppers, thus conveying the concept of neutralisation to a reasonable accuracy by counting the number of drops.

Developing content

In an orientation course, a teacher raised a question, "Is there variation in living things?" A biologist challenged the teachers to fetch any two identical leaves. An amusing but frustrating search ensued. Many a time the teachers thought they had found identical leaves, only to discover small differences on closer observation. A comparison of their fingers further proved that variations were inescapable. The faculty was excited. It had material for a new chapter which the teachers promptly named 'जीव जगत में विविधता' (*Jeev jagat me vividhata*).

The teachers generally exhibited an implicit faith in destiny. This was an impediment to logical analysis and had a spillover effect on the children. When presented with a specific case of two apparently identical fields giving different yields, they promptly attributed the difference to the predetermined destiny of the owners of the field. Factors like soil types, seed rate, fertiliser use, etc were totally ignored. This lack of rationality had serious implications on their ability to moderate discussions. A physicist, therefore, developed a unique chapter on chance and probability. Using

coins, dice and marbles, students were exposed to random numbers, distribution and the laws of probability. They simultaneously learned to handle large masses of data in the form of tables, histograms, graphs and averages.

A conscious decision has been made to avoid standard biological classification with its overdose of latinised terminology. Children are encouraged to build up their own systems of classification and to discover the underlying principles while doing so. As an example, the children naturally prefer classifying animals into groups such as 'animals that live on land', 'animals that live in water' and 'animals that fly', rather than into groups such as 'chordates' and 'non-chordates'.

The relatively elite value system of most of the teachers often places severe limitations on the learning system. This is one reason why we have been unable to base learning around active involvement in agriculture. Such barriers did not exist with children from landless and marginal farmer groups outside the schools in a non-formal programme. The social and cultural factors are also retarding factors. Teachers have been reluctant to dissect frogs to study anatomy and eggs to observe chick embryonic growth. Such activities would be possible if left to the children alone because of their uninhibited response and natural curiosity.

The crucial role played by the teachers and the children in curriculum development is now an accepted norm with us. The total learning time available is limited. The socio-economic contradictions and the needs of the rural community must influence educational priorities. These have been the touchstone for emphasising or de-emphasising subject matter. In spite of these limitations, we have been able to explore interesting phenomena in day-to-day life. The skies are studied in 'आकाश की ओर', (*Akash ki or*), the soil in 'मिट्टी', (*Mitti*), the crops in 'हमारी फसलें और समुहीकरण', (*Hamari phaslen aur samuhikaran*), the crop diseases and pests in 'फसलों के दुश्मन' (*Phaslon ke dushman*), the local geology in 'मिट्टी, पत्थर और चट्टाने' (*Mitti, patthar aur chattane*), and the local flora and fauna in a series of chapters such as 'जड और पत्ती' (*Jar aur patthi*), 'फूल और फल', (*phool aur phal*), 'कीडों की दुनिया' (*keeron ki duniya*) and 'जंतुओं का समुहीकरण' (*Jantuon ka samuhikaran*).

A commitment to learning through discovery, however, places constraints on exposing children to advanced scientific concepts arrived at through painstaking and sophisticated research. We have been unable to expose them directly to the intricacies of human anatomy, abstract chemical symbols and the theoretical concepts of atomic and molecular structure. For instance, to introduce the concept of molecules, the two experiments to be performed are, (*a*) laws of chemical combination, and (*b*) Brownian law of motion or limits of thinning in oil films. The former leads to the demand for the existence of a unit, while the latter leads to its finite size. Several textbooks quote the dissolving of sugar in water or the increase in solubility with temperature rise as the basis of molecular theory. This, however, has no direct bearing on the kinetic molecular theory. All the great scientists from Newton to Dalton saw sugar dissolving in water and did not arrive at the conclusion that there were molecules. It needed the experimental evidence of chemistry to develop such a concept. We prefer delaying such concepts till skills of experimentation and deduction are sufficiently developed for children to appreciate the experiments of others. (For situations like this, we suggest the use of appropriate supplementary reading material. The development of such material is a pressing need.)

Chemical symbolism, too, has been ignored. Instead, we have stressed manipulative skills like distillation, crystallisation, preparation and testing of gases, chromatography, neutralisation, etc. The concept of acids, bases and salts has been developed as a classification depending on colour changes of litmus, phenolphthalein, rose petal, turmeric, etc.

'Discovery' examinations

A few years ago, a voluntary group of scientists had introduced the discovery approach in a few urban schools. For almost two and a half years, the teachers and the children shared the excitement of experimentation. The days of memorising science were gone. As the Board examinations neared, an uneasy question was on the teachers' mind, "What kind of examination will the children have to undergo?" The concerned authorities refused to budge an inch and insisted that these schools should undergo the traditional Board examination. The teachers at once backtracked and spent the next few months spoon-feeding answers to probable questions.

We had from the very start insisted on total freedom to develop our own examination system. With unprecedented foresight, the Madhya Pradesh Government recognised us as an independent examining body for the 16 schools in science. Methods h been developed to test qualities independent observation, data col tion, free thinking and deducti We also seek to test the extent c child's readiness to innovate thro physical experimentation when fa with a new problem. This is achie partly through open-book writ examinations and partly through experimental test. Recall ability given only peripheral emphasis.

A similar commitment to s evaluation objectives is expressed official examining bodies, too. It claimed that their new 'object questions' achieve this. The follow example from an official examinat illustrates how these so-called obj tive tests merely test recall:

Choose correct answers and write the in your answer books.

1. Which of the following units is used denote the quantity of electric charge (i) Coulomb, (ii) Ampere, (iii) Vol (iv) Ohm
2. The enzyme pepsin is found in (i) intestinal juice, (ii) blood, (i stomach juice, (iv) bile juice.

A few samples of questions show how we have tried to m the objectives of the discovery proach are given below:

CLASS SIX

1. A scientist placed a few insects of tw different species in the middle of a lo glass tube. He sealed both its ends a placed it with one end in the sun a the other in the shade. An hour lat he observed that the two species ha separated, one collecting at the end the sun and the other in the shade.

What inference do you draw from th experiment?

CLASS SEVEN

2. A gas was collected in two test tub marked 'A' and 'B'. On adding copp sulphate solution to test-tube 'A black colour was produced. Test-tub 'B' was held upside down for a whil When copper sulphate solution wa later added to this test-tube, no blac colour was produced.

What properties of the gas are reveale by these observations?

CLASS EIGHT

3. You have been given a wooden strip some string and two *donas* (leaf cups) Using these, make a reliable weighin balance.

A striking change has taken pla in the attitude of the children towar such 'discovery' examinations. Th no longer feel the need to make la minute preparations. (No prepar tions can indeed be made for such a examination even if one wishes to We have today with us over 3,5(answer sheets of open-book writte tests and over 3,000 responses to ora experimental tests from evaluatio conducted over the last five year Each provides a valuable insight in the response to the discovery ap proach, the analysis of which ha

enabled us to continuously evaluate the efficacy and the relevance of our programme. Consequently, significant changes have been introduced from time to time.

The " Braintrust "

It has been a standing joke with us that during annual evaluations and orientation courses, a stone thrown in any direction would strike a PhD or a PhD-to-be. For, this is the time when our Resource Group members from AISTA, Delhi University, TIFR, IITs, post-graduate colleges of Madhya Pradesh and other places converge on Rasulia and Bankheri. Intense discussions carry on deep into the night and often spill over to the Delhi University Coffee House and TIFR West Canteen where remote villages like Dolariya, Junetha, Chandon and Nimsadiya acquire real meaning.

The participation of the Delhi University Group in the programme got official sanction from the University Grants Commission and the university authorities in 1973. It was the first time that a university group in the country was officially involved in improving school education. Faculty members spent a semester each at the field level. This close involvement has helped to ' conscientise ' the university group about grassroot level contradictions and conditions. A faculty member of a post-graduate college in Madhya Pradesh will soon be joining us on a three-year deputation under a UGC Fellowship. These have been important landmarks in the nation-wide debate on the social objectives of higher education. Education at the university level itself needs drastic changes, but such changes cannot precede, and certainly cannot be unrelated to, reform at the school level. In fact, meaningful reform at the school level will almost inevitably force reform at the universities. However, unless there is an official reorientation of the values of promotion and incentives, the vast potential in the nation's university system will remain untapped for the task of educational change.

Where do we go from here? A concrete proposal has been made to the Madhya Pradesh Government to take leadership of the programme into its own hands and to conduct a Pilot Project at the tahsil or district level. Educational innovation has limited value if it remains a working model. To become effective and socially meaningful, it must be merged into the wider educational network. Otherwise, it becomes merely an island of pilgrimage.

The potential of a multiplier effect in teacher-training has already been tested on two occasions. In May 1975, some teachers from the programme demonstrated the discovery approach to a batch of lecturers from the Basic Training Institutes of Madhya Pradesh at the Regional College of Education (NCERT), Bhopal. Five months later, they successfully trained a batch of teacher-recruits to the programme. The Hoshangabad Group can thus aid in building up a resource group within the Department of Education. Simultaneously, Government agencies like NCERT, State Institutes of Education and teacher-training institutes must question and redefine their traditional roles.

The Hoshangabad experiment, we believe, has succeeded in bringing the concept of learning through an environment-based discovery approach from the level of a seminar cliché-down to the plane of reality in village schools. The future success of the endeavour depends upon the political will of the Government and commitment from the academic community to better education in the schools of India's villages.

ASTRONOMY

A Cosmic Anomaly?

The discovery in 1965 by Arno Penzias and Robert Wilson of the microwave background radiation is considered to be the most significant cosmological observation since Hubble's discovery of nebular red-shift. This radiation has been measured at several wavelengths and its remarkable isotropy (to one part in 10^3) is taken to confirm the cosmological principle that the universe is homogenous and isotropic in the large.

However, anisotropies on a smaller scale, at a few parts in 10^4, are expected in this radiation background because we are looking at it from a frame which is not 'at rest'. The planet Earth moves round the Sun, which in turn moves round the centre of our Galaxy, the Milky Way, which itself is believed to have a velocity relative to the cosmological frame. Measurements of anisotropies on such a small scale will therefore tell us about these motions — if they exist.

Owing to interference from galactic emissions, these directional measurements have been difficult to make. The first indications of positive effects from such attempts were reported in the last 12 months. However, it is only recently that detailed findings have been published. G. F. Smoot, M. V. Gorenstein and R. A. Muller from the Lawrence Berkeley Laboratory and the Space Sciences Laboratory of the University of California at Berkeley (USA) have reported positive measurements of anisotropy in the cosmic microwave background (*Physical Review Letters*, **39,** 898, 1977). Their findings will generate considerable discussion among astronomers and cosmological theorists.

The experiment was conducted in a series of eight flights aboard the NASA Ames Earth Survey (U-2) aircraft. Anisotropy was detected at 33 GHz with a twin-antenna Dicke radiometer. This instrument measures the difference in the radiation intensities in the sky between two regions 60° apart and on opposite sides of the zenith. Precautions were taken to reduce all systematic errors well below the level corresponding to a temperature of 10^{-3} K.

Some 21 hours of data were statistically analysed and a temperature-direction curve was fitted in the following form:

$$T = T_o + T_1 \cos \alpha$$

[The main part (T_o) of the total temperature (T) is the same in every direction, whereas a small part depends on the angle α between the measured direction and a fixed direction in space.] The best fit was obtained by using $T_o = 2{\cdot}7°K$ (the average background temperature) with $T_1 = 3{\cdot}2 \pm 0{\cdot}6$ (10^{-3}K) and the fixed direction lying along a galactic latitude $\sim 54° \pm 10°$ and galactic longitude $\sim 245° \pm 15°$.

A cosine-anisotropy is explained by the motion of the Earth through the background space (the cosmological frame). In this case, these authors estimate the Earth velocity 390 ± 60 km s^{-1}, in a direction towards the constellation Leo. If we take into account the rotation of the solar system across the Milky Way, the velocity of the galaxy relative to the cosmological frame comes out to be 600 km s^{-1}, in the direction of galactic latitude 33° and longitude 261°.

While anisotropies of this order are not unexpected, these results are nevertheless disconcerting. The velocity of the Galaxy seems to be twice as large compared to previous estimates of galactic velocities in the cluster. Furthermore, the directic anisotropy seems to be unrelate another anisotropy associated the Hubble law of motion of gala This is the Rubin-Ford effect w suggests that our Galaxy is mo with a velocity 454 ± 125 km s an altogether different direction!

These results, therefore, indi conflicts with optical extra-gala astronomy. The authors do not out the possibility of intrinsic va tion in the microwave backgro Another implication — conside sacrilegious by most astronomer is that the microwave backgroun a galactic and not a cosmolog phenomenon! Because of the profo cosmological conclusions drawn fr the microwave background, it is hig desirable to conduct more such exp ments on it as the technology advan

J. V. NARLIK

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METEOROLOGY

Lightning Superbolts

Thunderstorms which are the sources of lightning flashes occur due to strong upward currents of moist air with the formation of cumulonimbus clouds. An extremely high amount of charge is built in the clouds due to the repeated frictional breaks of water droplets during the ascending and descending motions caused by the air circulation. Discharge results in lightning.

Normal lightning flashes as observed from ground stations are in the range of optical power of less than 10^{10} Watts within one-thousandth of a second. From ground-based sensors, no lightning flashes of intensity greater than about 10^{10} Watts have been observed excepting one case in Florida.

Recent studies of lightning flashes recorded by Vela satellites (B. N. Turman, *Journal of Geophysical Research*, **82,** 566, 1977) reveal an interesting series of flashes whose optical power far exceed the typical lightnings by 100 times or more. The Vela system consists of four satellites positioned in an inclined circular orbit equally spaced around the Earth. It is, therefore, possible for at least one satellite to be observing any particular region of the Earth at a given time. The major aim of this satellite system is to detect nuclear explosions by intense optical light flash wh accompanies them.

Soon after the Vela satellites came operational, an unusual kind background signals were obser simultaneously by the optical sens in two satellites. The optical sign of terrestrial origin resembled those " lightning first return strokes ", w the exception that the peak pov values of the flashes were far grea than anything detected earlier. Sin the time and location of such a flash termed a superbolt — are very ac rately known, they can be compar with other meteorological data corded in the same place and tin That these flashes are indeed due lightning were confirmed by the c relative study of cloud photograph weather reports and radio frequen signals in the region of superbolts. all these cases, the superbolts occurr at regions of intense thunderstorm

Winter storms over Japan and t north-east Pacific Ocean have pr duced a majority of these superbol The winter storms are noted for ve intense but infrequent lightning d charges to ground. Many of the d charges are from a positively charg region at the top of the cloud; typical thunderstorms the discharg are from negatively charged regio

The studies so far carried out ind cate that about two lightning flash in 1,000 exceed the optical power

10^{11} Watts and five in ten million exceed 3×10^{12} Watts with a time duration of the order of one millisecond.

Apart from the hundred-fold intensity increase of superbolts compared to normal thunderbolts, there is also a difference in the growth of the light intensity between the two. Whereas the normal lightning increases to peak intensity within a very short time (less than one ten-thousandth of a second) and then decreases comparatively slowly within a thousandth of a second, the superbolts take longer time to reach the maximum (order of one or two-thousandths of a second) and also have a comparatively longer decline time. Superbolts will give more detailed information about the mechanism of thunderstorms and related meteorological phenomena.

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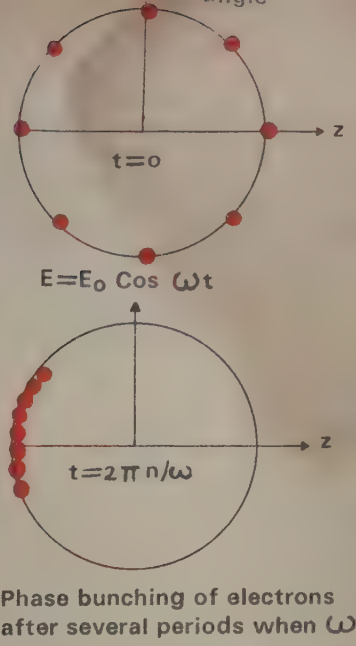

Phase bunching of electrons after several periods when $\omega \neq \omega_0$

ENVIRONMENT

Po and Pu in an Intertidal Food Chain

Plutonium is the first artificial element produced and utilised on a commercial scale. It is one of the most toxic radioactive elements. Of all the isotopes of plutonium, ^{239}Pu assumes the most significance, because it is a fissile material. Besides, ^{239}Pu (half-life 24,360 yrs), ^{240}Pu (6,580 yrs) and ^{238}Pu (85 yrs) are present in global fallout that originated as a result of nuclear weapon testing. The marine environment is the recipient of the major part of the fallout. Seaweeds have been identified earlier as major accumulators for fallout plutonium in sea water. ^{210}Po (Polonium) is one of the naturally occurring radionuclides produced from the decay of ^{210}Pb (lead) in sea water and is known to get highly concentrated in certain internal organs of large ocean fish like albacore. Recently Lanna Cheng, V. F. Hodge and R. A. Lewin from the Scripps Institution of Oceanography, USA, have reported (*Nature* **269,** 795, 1977) on the occurrence of polonium and plutonium in an intertidal food chain and their transfer from seaweeds to terrestrial food chain.

About 10^7 to 10^9 kg/year of seaweeds (kelp) gets washed ashore on the coasts of California. Samples of seaweeds and marine grass and adult flies of *Fucilia* species which feed on the decaying weeds in the area were collected. Beetles of *Cicindela* species which feed on the flies were also obtained from the sand. The scientists also studied laboratory-grown house flies and larva food to compare the levels of ^{210}Po in them and to compare the transfer ratios of the nuclide in the food chain.

The Scripps Institution scientists found that ^{210}Po values in kelp and marine grass (about 500 picocuries/kg) were about 250 times higher than $^{239, 240}Pu$ values (2 pCi/kg day) and in flies they are lower by a factor of 2. In both cases, Po-Pu ratios were found to be the same. The Po values observed in beetles were again lower than in flies by a factor of 2. The discrimination against Po and Pu as one goes up the food chain was thus evident. The authors estimate that the transfer of ^{210}Po and $^{239, 240}Pu$ from seaweeds to the terrestrial food chain may be only 0·2 per cent each of these nuclides. The radiation hazard to man arising from transfer of activity from seaweed to the flies and accidental inhalation of kelp flies will be very negligible.

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TECHNOLOGY

High-Power Microwaves

Microwaves are electromagnetic radiations of frequencies greater than 1 gigahertz (GHz), reaching up to the far infra-red region of the spectrum, that is up to 300 GHz (1 GHz = 1,000 megahertz (MHz)). Generation of microwaves in vacuum is difficult because of the finite transit time of the electrons passing between the electrodes. This finite transit time makes electrons susceptible to changes in the electric field between the electrodes. In microwave generators like Klystrons and magnetrons, the transit time variations are used to bunch the electrons. The bunching produces microwaves.

Due to technical limitations, the power outputs of the commonly used generators was in kilowatts, and rarely a few megawatts. Now a team of workers from the Naval Research Laboratory, Washington, USA, has reported generation of high-power microwaves of 90 to 100 MW power using a reflecting electron system by applying powerful pulses of ion beams to the anode. R. A. Mahaffey and others found this radiation in the presence as well as the absence of an axial magnetic field (Bo). In *Physical Review Letters* (**39,** 13, 1977) they attribute this emission to the phase bunching of oscillating electrons in the electric field of the system. The bunching is due to the dependence of the electron oscillation frequency (ω_0) on the electron energy. In the presence of a time-varying electric field, the electrons which are initially uniformly distributed, get bunched when the changes in the field are faster than the oscillation of electrons.

The electrons are emitted from a cathode and accelerated by the positive semi-transparent anode. The electrons passing through the anode form a virtual cathode on the other side of the anode. Due to the positive potential on the anode, the electrons remain in the system and keep oscillating between the two cathodes.

The generated radiation was seen in both the X-band (8·2 to 12·4 GHz) and the K*a* band (26·6 to 40 GHz) of the microwave spectrum. The all-round power emitted by the X-band was between 90 and 100 MW, corresponding to an efficiency of about 1·5 per cent. The corresponding power emitted in the K*a* band was about 10 MW. An important finding is that the observed frequency of the radiation varies with the applied voltage. Also, the frequency depends on the shape of the cathode and the distance between the real and virtual cathodes. The research team observed a drastic reduction and a resonance-like behaviour in the radiation power in an external axial magnetic field Bo. Besides, they found a linear increase of radiation with increase in Bo. The authors' theoretical model shows qualitative dependence of the emitted frequency on the transit time of the electrons which is consistent with the experimental observations. The results of the experiments are not likely to find immediate applications in the conventional microwave systems. The scientists feel that the model could be further developed to use the radiations as a plasma diagnostic tool.

A. V. SAPRE

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MANY FACES OF STATISTICS

How effective is a vaccine for polio? What is the effect of overweight on longevity? How did the different languages evolve? Who is the author of an anonymous work? What are the factors which will maximise production in a plant? What are the socio-economic effects of land reforms? What will be the year's crop output? These are some of the questions that statistics can help to answer. It can also answer some other curious questions. For instance, who really wrote *Hamlet*? And when was *Comedy of Errors* written? Does your height vary between morning and evening? Are more coconut trees in the Northern Hemisphere left-handed than in the Southern Hemisphere and, if so, what is the significance?

Enumeration of people and collection of statistics about the resources of a state have been practised since ancient times. And there is an interesting reference to the art of sampling in the *Mahabharata*. Today, statistics is a vastly enriched science, with an impressive array of new tools and techniques. It plays a vital role in basic research, in industry and management and in formulating national policies and programmes.

In the first article here, Dr. C. Radhakrishna Rao discusses several interesting scientific facts that statistical analyses have brought to light. "Statistics enables the scientist to have a full play for his higher creative potentialities — to discover new phenomena without allowing them to run riot . . . .", he says.

In the second, Dr. Jagjit Singh describes how new statistical techniques are used to increase industrial production. In the last article, Prof. V. M. Dandekar explains the principles behind sample surveys and their uses.

"A government can provide best benefits to the people if it takes policy decisions on the basis of a sound statistical study of problems. . . ." But then there are statistics which are convenient and statistics which are not.

STATISTICS IN SEARCH OF TRUTH

C. RADHAKRISHNA RAO

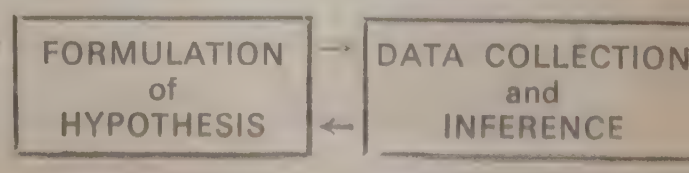
A beautiful theory, killed by a nasty, ugly little fact.

— Thomas H. Huxley

How do we acquire knowledge about natural phenomena? What are the thought processes involved and investigations to be carried out? How do we judge from observed data whether we have obtained the right or requisite knowledge? These questions have indeed baffled the human intellect and remained for long a subject for philosophical discourses. However, recent advances in logic and statistical science have enabled us to provide satisfactory answers to these questions.

Knowledge of a natural phenomenon is usually abstracted in terms of laws which enable prediction of future events within the requisite limits of accuracy. Thus we have Newton's laws of motion, Boyle's law connecting pressure and volume of gases, Bohr's atomic model, Mendel's laws of inheritance, Mendeleyev's periodic law of elements, etc.

How do these laws or theories get established? There is a scientific method. First, a law is formulated as a provisional hypothesis to explain certain observed events. Second, the consequences of the hypothesis are worked out by rules of deductive reasoning and verified by further observations collected through carefully designed experiments. If the data contradict the hypothesis, it is discarded, and a fresh one is formulated. Otherwise, it is provisionally accepted and is given the status of a law — with specified limitations and scope of applications. This leaves open the possibility of the law being replaced in course of time by a more universal one supported by a wider set of data. The scientific method of investigation involving the logical cycle, Hypothesis-Data-Hypothesis, can be schematically represented as follows:



Of these two phases, 'Data Collection and Inference' comes under the realm of statistics, while 'Formulation of Hypothesis' falls in the field of enquiry. Both these processes require a high degree of imagination and technical skills to make real scientific progress. One can emphasise that *scientific laws are not advanced by the principle of authority or justified by faith or medieval philosophy; statistics is the only court of appeal to new knowledge.*

Through appropriate data analysis designed to test given hypotheses and to provide clues for possible alternatives, statistics enables the scientist to have a full play for his higher creative potentialities — to discover new phenomena without allowing them to run riot and waste in advancing new concepts which have no relation to existing facts. In the process, statistics gets enriched through research on new methodology that may be required in the analysis of special kinds of data.

What role does statistics play in initiating a new discovery? The question is difficult to answer, for scientific research itself is still an art or craft and not a science. A discovery is, no doubt, a flash of imagination. But it happens only to the prepared mind which is able to sift the evidence from the debris of rejected ideas and look for unexpected and isolated embers to start a fresh fire. The statistician's job is to extract all available information from given data to make the figures tell their own story and reveal what is concealed in them. Depending on his experience and knowledge of the area of enquiry and varying degrees of collaboration with experts in the field, a statistician can make deeper probes into data to understand the underlying phenomena.

However, acquisition of knowledge need not always be in the form of scientific laws or theories. How much wheat will be produced in the current crop season? Does smoking cause cancer? Was a particular skull, dug

out from an ancient grave, that of a man or a woman? Who wrote the play *Hamlet* — Shakespeare, Bacon or Marlowe? What is the exact location of the brain tumour in a patient's head? What is the effect of overweight on longevity? How did the different languages evolve? Is the last born child more intelligent than the first born? How does one test the effectiveness of a vaccine for polio? Does seeding of cloud produce rain? These are a sample of a few questions raised to acquire new knowledge, and which have been answered through statistical inference.

In some cases, the knowledge is useful in taking decisions in daily life; in some others, it may be for historical record; and in a few others, it may be just to satisfy intellectual curiosity. Without going into the technicalities, let us consider some examples of statistical approach in search of truth or new knowledge.

Circadian rhythm

If you are asked what is your height, you will, no doubt, have a ready answer — a certain number. Someone might have measured your height some time and given you that number. But you might not have enquired how that number qualifies to represent your height. And if you, indeed, had, the answer would have been, that it is an observation obtained by carefully following a 'prescribed procedure for measuring height'. For all practical purposes, such an operational definition of height may be satisfactory. But then other questions arise. Does the characteristic we are trying to measure (in a prescribed way) depend on the time of the day at which the measurement is taken? And, if it is variable, how do we specify its value? For instance, is there a difference between the morning and evening (true) heights of an individual? If so, what is the magnitude of the difference and does it have any physiological explanation?

A simple statistical investigation can provide the answer. Careful determinations of morning and evening heights of 41 students in Calcutta showed an average difference of 9 mm, the morning measurement being higher in each case. [Rao, *Sankhya* **19,** 1957, pp. 96–98.] If, in fact, the heights of an individual at different times of the day are the same, then any observed difference is attributable to errors of measurement which may be positive or negative with equal probability. In such a case, the probability that all the 41 differences are positive is of the order of 2^{-41} which corresponds to an event which occurs less than 5 times in 1 million experiments, indicating that the odds against the hypothesis of no difference in heights are extremely high. We seem to *grow* by about 1 cm when we are asleep at night and *diminish* by the same length while we are at work during the day!

Having established that the morning and evening heights differ, the next question may be, which part of the body elongates more when we are asleep? To examine this, separate determinations were made of the lengths between certain points marked on the body, both in the morning and in the evening. It was found that the entire difference of about 1 cm occurred in that part of the body along which the vertebral column is located. A plausible physiological explanation is that during the day the vertebrae come closer by shrinkage of the cartilages between them; these revert to the original position when the body is relaxed.

Why do teachers prefer to lecture in the morning hours? It is said that both teachers and students are fresher in the morning and there is greater rapport between them. Is there any physiological explanation of this phenomenon?

The change in the plasma cortisol evels seems to explain our alertness n the morning hours. In normal ubjects, the cortisol level is about 6 μg/100 ml at 8 AM and it radually drops to 6 μg/100 ml by 1 PM (a decrease of 60 per cent). The rise of cortisol in the morning vakes you up and the trough in the vening puts you to sleep. Consequently we are alert in the morning nd gradually tend to be sluggish as he night falls.

Several physiological characteristics f the human body, in fact, vary uring the day as was observed in the ase of height; each has a particular ircadian rhythm, that is, it follows a 4-hour cycle. The importance of tudying such variations, known as Chronobiology, for optimum timing of reatment of patients has been stressed y Halberg (*Chronobiologia*, 1, 974, pp. 22-64). For instance, a dose of drug which is right at one time of he day can be found to be wrong at nother time; the action may depend n the levels of different biochemical ubstances in the blood at the time of dministering the drug. Chronobiogy is becoming an active field of esearch with extensive possibilities of pplication. Much progress in these tudies is due to statistical techniques eveloped to detect and establish eriodicities in measurements taken ver time.

How famous are you?

Deathbed scenes in which a dying mother or father holds on to life until after the long-absent son returns home and dies immediately after are too familiar in movies. Do such things happen in real life? Can some people postpone their deaths until after a special event takes place? It is believed that famous people do so with respect to their birthdays to which they attach some importance. A study by David P. Phillips (*Statistics: A Guide to the Unknown*, pp. 52–65), seems to be consistent with the notion.

Phillips obtained data on months of birth and death of 1,251 famous Americans; the deaths were classified by the time period between the birth and death dates as shown in Table 1.

Sample 1 corresponds to very famous people listed in *Four Hundred Notable Americans* and Sample 2 to people mentioned under the category 'Foremost Families' in three volumes of *Who Was Who* for the years 1951–60, 1943–50 and 1897–1942.

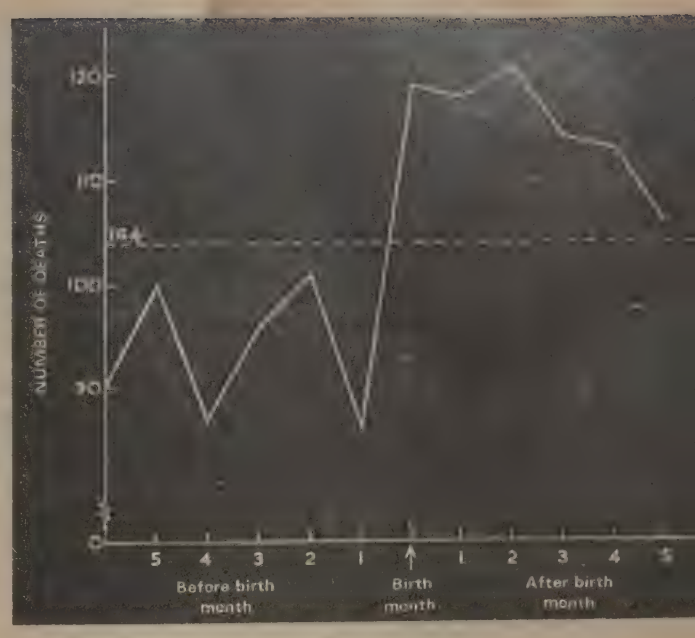
If the date of death has no relationship with that of birth, then the expected number of deaths for each time period in Table 1 is 1,251/12 = 104 (approximate) as against the numbers 90, 100, 87, . . . for the total of two samples. These numbers are represented in a graph (alongside) where the dotted line is drawn at 104·3, the expected number of deaths, for comparison. The results are indeed striking.

The numbers of deaths 'before the birth month', fall below the dotted line, with a total of 560 against the expected number of 626. Above the dotted line are the number of deaths in the 'birth month and after', a total of 691 which is 10 per cent in excess of the expected figure. What is more striking is a sudden dip (17 per cent less than expected) in the number of deaths for one month before the birth month and a steep rise (14 per cent more than expected) for the birth month and one month after. Thus there is a noticeable tendency to stave off death until after birthday.

Such a tendency seems to be more pronounced in the case of very famous people listed in *Four Hundred Notable Americans* (see sample 1 in Table 1). In their case, the number of deaths before one month is 45 per cent fewer than expected, while for the others (not so famous) it is only 7 per cent less. The corresponding figures for excess of deaths in the birth month and one month after is 16 per cent for very famous people and 7 per cent for the others.

The importance of being left-handed

It is not generally known that a coconut tree can be classified as left-handed or right-handed, depending on the direction



Number of deaths of famous men before, on and after the birth months

of its foliar spiral. Some years ago, an investigation of this aspect was undertaken by T. A. Davis at the Indian Statistical Institute (ISI). The study offers a good example of a statistical approach in eliciting information from an understanding of nature.

Why are some trees left-handed and others right-handed? Is this character genetically determined? The question can be answered by considering parent plants of different combinations of foliar spirality and scoring the progeny for the same characteristic. The data collected for this purpose are shown in Table 2. The ratios of left to right are nearly the same for all combinations of parents indicating that there is no genetic basis for left- or right-handedness.

TABLE 2. PROPORTIONS OF LEFT- AND RIGHT-HANDED OFFSPRINGS FOR DIFFERENT TYPES OF MATING

Pollen parent	Seed parent	Progeny		
		left	:	right
Right	Right	44	:	56
Right	Left	47	:	53
Left	Right	45	:	55
Left	Left	47	:	53

So the ratio appears to be entirely determined by external factors which act in a random way. But why is there a slight preponderance of right-handed offsprings (about 55 per cent) in the observed data (Table 2)? There must be something in the environment which tends to give a greater chance for a tree to twist in the right direction. And if so, does this chance depend on the geographical location of trees? This could not be determined until data from various parts of the world could be collected. It was then found that the proportion of left-handers is 0·515, in samples from the Northern Hemisphere, and 0·473 in the Southern Hemisphere. The difference may be due to the influence of the one-way

TABLE 1. NUMBER OF DEATHS BEFORE, DURING AND AFTER THE BIRTH MONTH

	months before						birth month	month after					Total
	6	5	4	3	2	1		1	2	3	4	5	
Sample 1	24	31	20	23	34	16	26	36	37	41	26	34	348
Sample 2	66	69	67	73	67	70	93	82	84	73	87	72	903
Combined	90	100	87	96	101	86	119	118	121	114	113	106	1,251

rotation of the Earth, which also explains the phenomenon of the bathtub vortex which, under well-controlled conditions, is shown to be counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

The investigations would have remained somewhat academic in character if Davis had not been curious to look for some features in which the left and right trees could possibly differ. He compared the mean yields of left and right trees in a plantation over a 12-year period; he was surprised to find that the former yielded 10 per cent more than the latter. Although no explanation could be offered — the question needs to be pursued and might not be easily solved — the empirical conclusion is of great economic importance. For, by selective plantation of left trees alone, the yield could be increased by 10 per cent! Davis has raised the question whether left-handed women are more fertile than the right-handed. The answer may be of interest in the context of family planning.

In fact, the phenomenon of right- and left-handedness seems to be universal in the plant kingdom. You may not have noticed flowers with right and left spiral arrangement of petals on the same plant in your garden. And there are creepers which twine up only in a right spiral, and others only in a left spiral. Experiments at the ISI to change their habits ended in a failure. They seem to react violently at any such attempt.

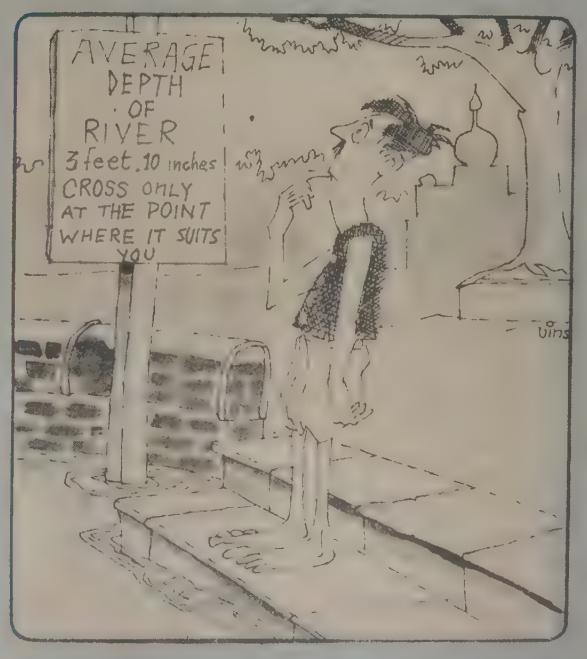
It is also strange that all living organisms (except possibly very low forms) are left-handed in their biochemical make-up. All amino-acids, except glycin, exist in two forms — L (levo) and D (dextro). The L and D forms are mirror images of each other and are called the left- and right-handed molecules, respectively. All the 24 amino-acids found in plant and animal proteins and even in simple organisms like bacteria, moulds, viruses, etc are left-handed. Both right-handed and left-handed molecules have exactly the same properties, and life might have been possible with only D acids or even with a mixture of some L and some D acids. Is it then an accident of nature that living organisms have evolved in the L-system rather than in the D-system? Or, is it possible that the left-handed molecules are inherently more suited to the construction of living organisms? There may be some mysterious force in left-handedness which science has yet to explore.

STATISTICAL THINKING

H. G. Wells had remarked: Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write. Today, it is the age of statistics. Advertisers use statistics to extol the virtues of their products. Government agencies quote statistics to show that their policies had beneficial effects. A meteorologist reports that the odds are 9 to 10 that it rains tomorrow. Can the layman interpret these statements in the right way to take useful decisions? For this, it may be necessary to understand basic statistical ideas and possible uses and misuses of statistics. We shall consider a few examples of fallacious statistical thinking and misleading statistical arguments and show how to avoid them and recognise them when others do it.

One of the most basic statistical needs is simply to describe a population with respect to a characteristic or a number of characteristics possessed by individuals or units constituting the population. A simple description known to every one is the average value of a characteristic, such as the average height of males in India, per capita consumption of rice, the average life of an electric bulb, and so on. In some cases, it is enough to know only the average. For instance, knowing the per capita consumption of rice, the total quantity of rice needed to feed a population can be computed and this figure is useful in making policy decisions on the production of rice in the country and imports. But in many cases, the average does not tell the whole story. Imagine a non-swimmer being advised to cross a river on foot because his height is more than the average depth of the river!

Every year, the Government publishes per capita national income, proclaiming that there has been a substantial increase over the previous year. The Government would like us to believe that the increase indicates economic progress and that the standard of living has been steadily increasing. Can we measure the economic well-being of a community



by only the average income? An increase in the average may not necessarily mean that all sections of community have equally benefited might even be that the poor are w off and the already well-to-do making more money. What is m important in such cases is perhaps measure of disparities of income ra than the average level of income. is reminded of what Lord Jus Mathew said: When I was a yo man practising at the bar, I lost a g many cases I should have won. A got along I won a great many cas ought to have lost; so, on the wh justice was done.

Of course, there are other measu of location like the median or m which are more appropriate than mean in some situations. The med is a value such that exactly half individuals in a population have lo values and exactly half have hig values. The mode is the figure t occurs most often. These measures not unduly influenced by extre values and are, therefore, useful problems such as comparison of comes of two communities or of same community over a period of ti However, they have other limitatio For instance, one cannot compute total for a population knowing median or the mode.

Then there are ratios and perce ages used to confuse the laym Instead of giving the actual quantiti figures are often reported as perce ages with respect to some base value order to stress their importance. So time ago the newspapers reported th the police had brought down number of homicides in a city by per cent within a year. Fifty per c — an impressive achievement! the actual drop was from eight to fo which does not mean much. The sa percentage of reduction obtains if homicides dropped from 800 to 4 But here the actual quantities seem be more impressive than the perce age.

A few examples were given to sh the inadequacy of measures of locati such as the average, median and t mode in describing a given populati and the pitfalls in inferences based them. This is because the individua in a population usually differ substa tially from one another and this mig make a difference. In such cases, may compute a measure of dispersi (differences between individuals) supplement the measure of locatio Suppose $x_1, \ldots, x_n$ are measuremen of n individuals arranged in increasi order of magnitude. One measure dispersion is the range $R = x_n -$ (the biggest minus the smallest Another measure is the standa deviation s which depends on all t values, where $s^2 = \Sigma (x_i - \bar{x})^2 \div$ which is the average of the square deviations of the individual values fro the average $\bar{x} = (x_1 + \ldots + x_n)/$

Thus we nave two quantities $\bar{x}$ and s, to describe a population. The former measures the general magnitude of values and the latter the spread of values. A small value of s indicates more homogeneity of the individuals with respect to the character under study.

In many problems, $\bar{x}$ and s provide a good description of a population. They can be used to compare two populations or assess the changes taking place in a population over time. But they may not be adequate in all situations to answer specific questions. Suppose that the incomes of a large number of individuals have $\bar{x} = 25$ and $s = 10$. This information is not sufficient to compute, for instance, the percentage of individuals below the poverty line, say Rs. 20. Again, suppose that we want to determine the quantity of bulbs to be stocked by an establishment for replacing the fused ones after 100 hours of use. This number cannot be computed knowing only the mean and standard deviation of the life of bulbs. Thus, in many practical problems one needs to have what is called a frequency distribution such as the following which specifies the percentage of individuals in different ranges of values of a characteristic. From this, we know that about 64 per

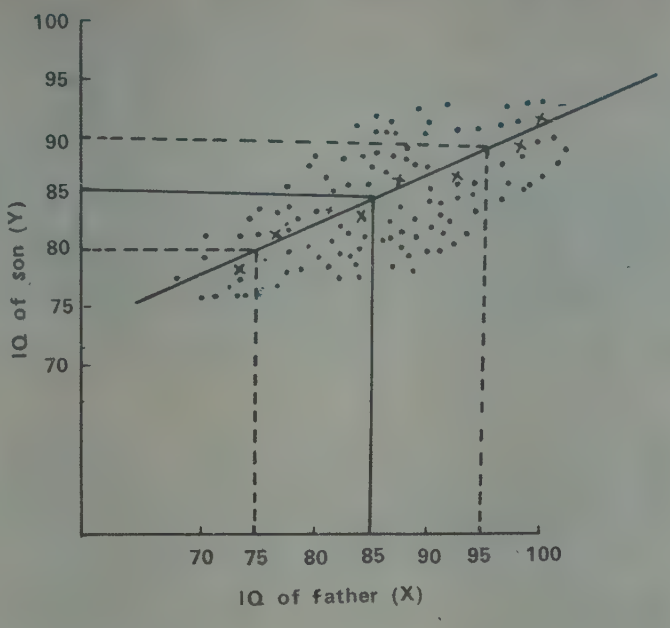
	Number of hours				
Life of bulb	0–50	50–100	100–150	150–200	over 200
Percentage	40	24	16	9	11

cent of the bulbs burn out before 100 hours. So, if the establishment has 1,000 light points, the number of replacements after 100 hours of use will be about 640.

We have considered some examples involving the study of a single characteristic in a population. Often, it is necessary to consider two or more characteristics and examine their interrelationships. As an example, let us take a family as a unit, and in each family measure (x), the IQ of the father and (y), that of a son. If we have such pairs of measurements (x,y) on a large number of families, we can plot them in a chart as shown.

In the chart, a point represented by a cross ($\times$) represents the average IQ of sons of fathers with a specified IQ. The cross points are close to a line which is called the regression line of son's IQ on his father's IQ. Thus the y coordinate of any point on the regression line represents the average IQ of sons of fathers with IQ equal to the x coordinate. One can make the following observations based on the distribution of points in the chart.

(1) The average IQ of sons increases with increase in the IQ of the father. This establishes some kind of relationship, though not of a one-to-one type. When the values of x and y are plotted in their standard deviation units, the slope of the



Points represent the IQ's of father and sons. The regression line is for predicting son's IQ for given father's IQ

regression line as measured by the tangent of the angle it makes with the x-axis lies between -1 and 1, and at the extreme values (-1 and 1), the relationship becomes exact (one-to-one). When the slope is zero, there is obviously no relationship. Thus the strength of the relationship may be measured by the slope of the regression line, which is called the correlation between x and y and is denoted by r. This can be directly computed from the observed pairs $(x_1,y_1), \ldots, (x_n,y_n)$ by the formula

$$r = \frac{\Sigma (x_i - \bar{x})(y_i - \bar{y})}{[\Sigma(x_i - \bar{x})^2 \Sigma (y_i - \bar{y})^2]^{1/2}}$$

(2) The average IQ of all fathers is 85 which is nearly the same as the average IQ of all sons.

(3) The average IQ of sons of fathers with $IQ = 95$ is only 90. This shows that intelligent fathers have on the average less intelligent sons. On the other hand, when the fathers' IQ is below the average, say, 75, the average IQ of the sons is 80 showing that not-so-intelligent fathers have on the average more intelligent sons. This is an interesting phenomenon first observed by Galton, who called it regression and hence the name regression line referred to earlier. Since the number of fathers with IQ round about the average is fairly large compared to those with large or small IQs, Galton observed, as a consequence of the regression phenomenon, that the ablest of all the children of a few gifted parents is not likely to be as gifted as the ablest of all children of a very great many mediocre parents. An exceptional man is more frequently found to be the exceptional son of mediocre parents than the average son of an exceptional parent.

It is important to know in what way the relationship between two variables x,y, such as the IQs of father and son, can be interpreted and used. For instance, the regression line can be used to predict a son's IQ, given the father's IQ (by reading off the y value of the point on the line corresponding to given x value). Of course, the prediction cannot be exact unless the correlation is unity, the error depending on the magnitude of the correlation.

Relationships between variables are frequently used for predicting one variable given the others, or controlling one variable by causing others (known as instrumental variables) to take suitably determined values. For instance, the prices of commodities are highly correlated with the amount of money in circulation. So in order to control the prices, the government may introduce measures to reduce the amount of money in circulation.

Such applications are not always valid. A strong relationship between variables may obtain under different conditions. But not all observed relationships can be used for prediction purposes. For instance, the number of thefts is found to be more in the summer months than in the winter months, which may show a high degree of correlation between number of thefts and temperature. This does not mean that by inducing people to commit more thefts the temperature can be made to rise, or that by increasing police surveillance and controlling the number of thefts, the temperature could be brought down. Two variables may correlate because one is the cause of the other. But the roles of cause and effect may not be reversible.

The correlation between two variables may be induced entirely by a third variable, in which case the observed relationship is spurious and cannot be used for prediction. For instance, the number of stork's nests and human babies show a high degree of correlation. This does not mean that the human population can be controlled by destroying the stork's nests (or the storks). The observed correlation is not due to any intrinsic relationship between the two variables but to the fact that as the population and, hence, the number of buildings increased, the number of places for storks to nest increased.

There is a story that a child asked the father to request the pilot of an aircraft, in which they were travelling, not to switch on the *Fasten Seat Belts* sign because every time he did, the ride got bumpy.

Thus one has to be careful in using certain variables as instruments to control the others. One has to make sure that there is a cause and effect relationship and that the variables which cause can be identified.

C. R. R.

Statistical diagnosis of diseases

Some years ago anthropologists were faced with the problem of sorting out ancient skeletal material into those which belonged to males and those which belonged to females. The problem becomes very difficult if a decision has to be taken on the basis of only a small part of the skeleton such as a mandible (lower jaw bone). The famous statistician, the late Sir Ronald Fisher, found an ingenious method. If $x_1, \ldots, x_n$ are some measurements (such as height, width, etc) on the mandible, the rule suggested was to classify it as belonging to a male if $a_1 x_1 + \ldots + a_n x_n$ exceeds a specified value c and to a female otherwise. The function $a_1 x_1 + \ldots + a_n x_n$ where the coefficients $a_1, \ldots, a_n$ are suitably determined is called a discriminant function and c is a threshold value differentiating between the sexes. The rule worked remarkably well when applied to mandibles where the sex was known.

This simple method opened up a wide field of applications, the most interesting being in life-saving situations. Physicians usually diagnose disease in patients by a few symptoms or diagnostic tests. The fact that two physicians can differ in the diagnosis of even a simple case on the basis of the same test results shows that the diagnostic tests used may not be adequate and each physician uses his own experience in addition in deciding on the nature of a disease. Of course, the number of diagnostic tests could be increased (subject to limitations of costs), but the problem arises as to how effectively they can be used. Not all physicians may have the ability or the experience to comprehend a huge mass of data, often confusing with seemingly contradictory test results, to piece together tiny bits of evidence supplied by individual tests and arrive at the best possible conclusions. To meet situations like this, the statisticians developed what is called multivariate analysis (as different from looking at each test result separately), by which the information in individual measurements (like diagnostic tests) can be combined most effectively to answer a specific question (like, what is the nature of the disease?). Utilising the records on past patients and the experience of the best available doctors, we can construct a discriminant function based on numerous diagnostic tests and also determine threshold values to distinguish between diseases. The task of making the necessary computations and updating the discriminant function by using fresh evidence provided by current cases and by adding newly discovered diagnostic tests is indeed very complex. For this purpose modern high speed computers are pressed into service, and hence the term computer diagnosis. The physician has only to feed the data on a given patient into a computer to obtain the best possible diagnosis based on all the available wisdom in the world. For instance, computer diagnosis using hundreds of measurements is now commonly used in complicated heart diseases.

Literary style quantified

The use of statistics is not limited to scientific investigations only. Judging from the articles appearing in learned journals in any field of enquiry, scientific or otherwise, one is struck by the emphasis on the quantitative approach and statistical inference. The least expected areas are the creative arts. We shall discu a few applications of statistics literature and study of languages.

Plato's works survived for mo than 22 centuries and his philosophic ideas and elegant style have bee widely studied. Unfortunately, n body mentioned or perhaps nobo knew the correct chronological ord in which his 35 dialogues, 6 sho pieces and 13 letters appeared. T problem of chronological seriation Plato's works was posed a century a but no progress was made. T statisticians took up the problem few years ago, and have now provide what appears to be a logic solution.

The statistical method starts establishing for each pair of works a

DESIGN OF EXPERIMENTS

Statistics as a scientific discipl deals with techniques for drawi inferences from data. Problems drawing inference are usua formulated as of testing of hyp theses (for example, seeding clouds produces rain), estimating u known parameters (per capita co sumption of rice in India) and taki decisions (the number of cars to produced next year). If inference is be based on data, then that data mu be generated in such a way that th provide the relevant information on t problem under investigation, an ideally, the maximum possible inform tion subject to given (fixed) resourc for acquiring data. Methods of da collection or generation are, therefo as important, if not more, as metho for analysing them. Much of t research in statistics during the la 50 years has centred round da collection techniques through what a known as Sample Surveys and Desig of Experiments.

A survey is relevant when we wa to estimate a natural aspect of population, such as average incon and land owned. Problems of this ty are undertaken by the National Samp Survey in India (see "Statistics National Planning", p. 40). It is matter for an experiment if we wa to test a hypothesis on the relati effects of different treatments on indiv duals of a population. For instanc does variety A of rice yield more tha variety B on a given piece of lan does smoking cause lung cancer in a individual? is a newly discovered va cine effective for birth control?

How do we collect and analyse da to answer such problems? We sha consider a specific problem — wheth a given vaccine B reduces the chan of conception or not. An investigat may argue: the conception rate ov a period of time for 100 women wh were vaccinated with vaccine B w

Right and left-twisting *Hibiscus cannabinus* flowers

wer than that for the general popula-
on in the same period, and, therefore,
accine B was effective. Such an argu-
ent is obviously not convincing. It
ay be that the 100 women chosen
ere normally less fertile and/or their
xual behaviour was different from
e rest of the women, in which case
e observed difference could not be
lely attributed to the vaccine. It is
nportant that we make sure that the
eated and untreated groups are simi-
r in all relevant aspects except for the
eatment so that any observed differ-
ce could be attributed to the treat-
ent. The untreated individuals con-
itute what is called the control group;
us we have the famous principle of
cal control in all experimental work,
ithout which valid comparisons of
eatments are not possible.

How do we achieve local control? n the problem under discussion, this ay be done by matching of indivi-uals. We choose a pair of women who re nearly of the same age, of the same aste and have the same fertility udged by the previous number of hildren, family history, etc) and hoose one of them for treatment and e other for control. If the two women appen to be identical twins, we have n ideal matching. If not, we have to atch the individuals available to the xtent possible. But another question rises: which one of the individuals in e matched pair is to receive the eatment? This is better decided at andom, for instance, by tossing a coin. his is known as the principle of *ndomisation;* it ensures that no investi-ator bias is involved in assigning eatments to individuals and, what is ore important, in the absence of erfect matching, provides the logical asis for statistical interpretation of esults.

How many pairs of women should e included in the experiment? The nswer is not simple, except that the ore the better. The number will epend on how large the effect of ncontrollable factors is, that is, how large the natural differences between women in each matched pair are. We need only a small number if the matching is good. Otherwise, a large number is needed to smooth out the effect of other uncontrollable factors which may cause differences in fertility and bring to focus the actual effect due to the treatment. We thus have the third important principle of a well-designed experiment, namely, *replication*, the first two being *local control* and *randomisation*. These were first enunciated by R. A. Fisher, the originator of Design of Experiments.

There are other problems to be taken care of, specially in a medical experiment like the one we are considering. It may so happen that a woman who knows that she is in the experiment but has not been given the vaccine might behave differently from the one who knows that she has received the treatment. So it is important that a woman in the experiment should not be aware whether she is under treatment or not. This can be ensured by what is called *placebo control approach*. A placebo resembles the actual treatment in all respects except that the active ingredient is not used. Thus, if the treatment involves giving an injection of a fluid with the vaccine B, then the placebo will also be an injection, but of a similar-looking fluid without the vaccine. One of the women is given the actual injection and the other the placebo without telling them what they have actually received. No doubt, there are some ethical problems involved in such an experiment which have to be considered and resolved in a satisfactory way before starting the experiment.

In some experiments, investigators' observations might be biased if they knew which of the individuals were treated and which received the placebo. This can be avoided by giving a code number to each vial of injection so that no one involved in giving the vaccination and the follow-up study could know who received the treatment. An experiment in which both the subject and the investigator are kept ignorant of the treatment given to each individual is called a *double blind* experiment.

With data obtained by such an experiment based on the principles of local control, randomisation and replication, and taking precautions such as placebo control and double blind approach, it is only necessary to apply routine statistical analysis to test a given hypothesis. It is clear that if we want to compare the relative effects of three vaccines, we have to choose matched triplets and assign the three treatments at random to the three individuals in a triplet, and so on.

I have described a clinical experiment, but the same principles can be followed in designing an experiment in any field of enquiry. Suppose that an agricultural scientist wants to find out which of a given set of grain varieties gives the highest yield. Corresponding to a matched group of individuals in a clinical trial we have a compact set of plots constituting a block. A subset of varieties (if not the complete set) are assigned at random to the plots. We use a number of blocks for the experiment corresponding to the replication of matched groups in a clinical trial. Such an agricultural experiment is known as a randomised block experiment. The yields of varieties observed on the plots can be analysed by a statistical technique called Analysis of Variance. The idea behind this method is very simple. We compare the observed differences between varieties with what is expected if the varieties are not different, which is calculable from the experimental data itself. The hypothesis of equality of varieties is rejected if the former is somewhat larger than the latter.

Design of experiments offers a firm basis for drawing conclusions from data. Much of the experimental data generated by scientists go waste or lead to wrong conclusions because of lack of adequate controls and bias in assignment of treatments.

C.R.R.

ndex of similarity. In a study ndertaken by Lilian I. Boneva *Mathematics in Archaeological and Hisorical Sciences*, 1971, pp. 174–185), the ndex was based on the frequency listribution in each work of 32 posible descriptions of the last five yllables of a sentence, technically alled clausula. Using the only asumption that works closer in time period would be more similar than hose far apart in time, and no other extraneous information, a method has been evolved to infer the chronological order of different works.

When did Shakespeare write *Comedy of Errors* and *Love's Labour Lost*? The dates of publication of most of Shakespeare's works are known through written records, but in some cases they are not known. How can the information on the known dates of some publications be used to estimate the unknown dates? Yardi (*Sankhya*, **7**, 1946, pp. 263–268) examined this problem by using an appropriate statistical methodology and without using any external evidence. In each play, he considered the frequencies of: (*i*) redundant final syllables, (*ii*) full split lines, (*iii*) unsplit lines with pauses, and (*iv*) the total number of speech lines. With the literary style so quantified, Yardi studied the secular changes in style, over the long period of Shakespeare's literary output, from the plays with known dates of publications. He then inferred by interpolation the possible date of publication of *Comedy of Errors* as in the winter of 1591–1592, and that of *Love's Labour Lost* as in the spring of 1591–92.

A closely related problem is that of disputed authorship or the identification of the author of an anonymous work. A recent example of such a study is what is called the *Federalist Papers* written in 1787–1788 by Alexander Hamilton, John Jay and James Madison to persuade the citizens of New York to ratify the constitution. There were 77 papers signed with a pseudonym 'Publicus' as was common in those days. The exact authorship of many of these essays have been identified, but the authorship of 12 is in dispute between Hamilton and Madison. Two statisticians, Frederic Mosteller and David

Wallace (*Inference and Disputed Authorship*, 1964, Addison-Wesley) came to the conclusion that Madison was the most likely author of the 12 disputed papers. The statistical approach in such cases is to first study in quantitative terms each individual author's style from his known publications and to assign a disputed work to that author whose style is closest to the disputed work.

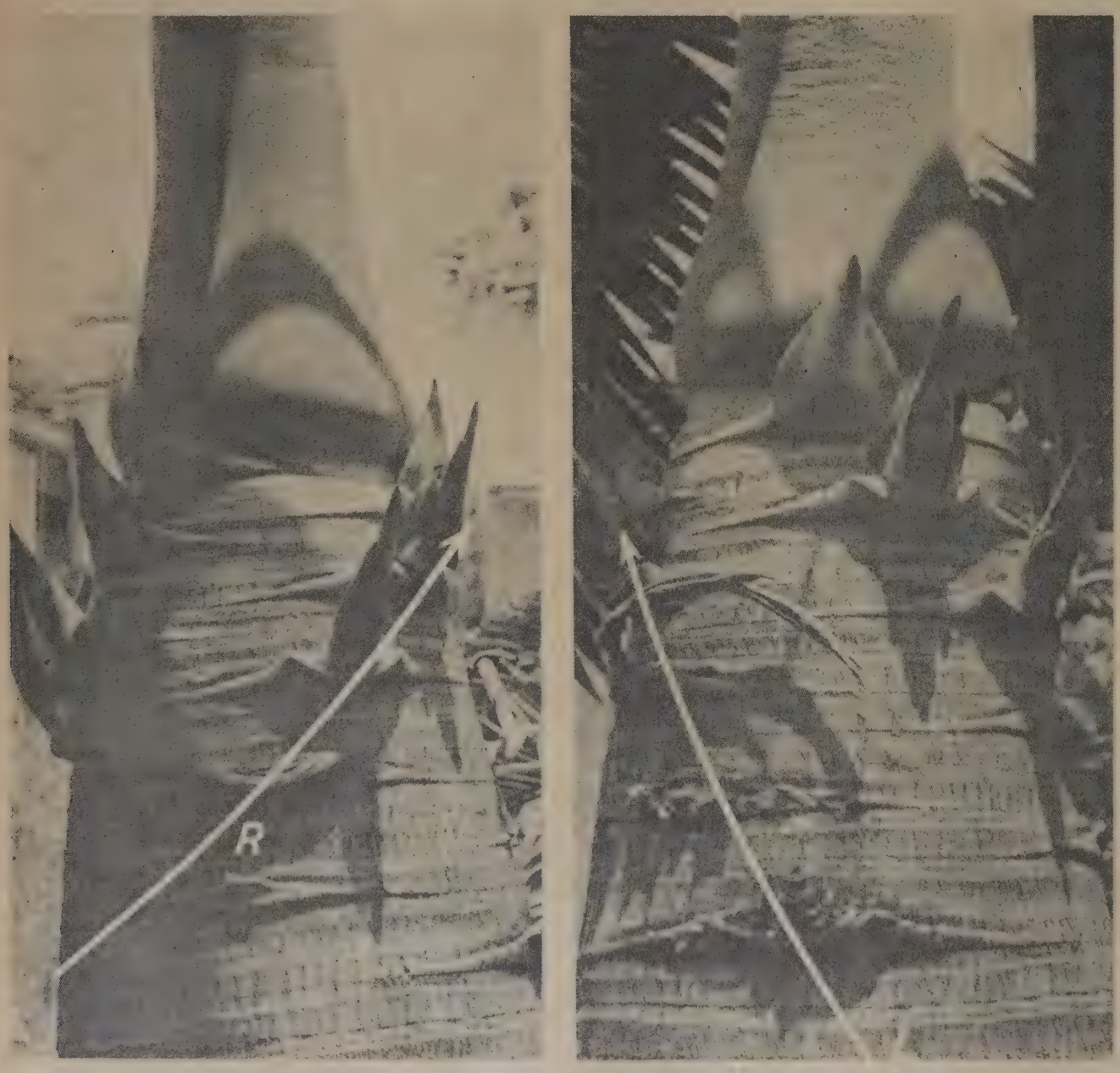
Filiation or linkage of manuscripts is another problem solved by purely statistical techniques. A recent study by Sorin Cristian Nita (*Mathematics in Archaeological and Historical Sciences*, 1971, pp. 401–409) related to 48 copies of the Roman chronicle, *The History of Romania*, some of which are copied from the original, and the others from the copies of one or more removed from the original. The problem was to decide, as far as possible, the original version of the work and the whole genealogical tree of the existing manuscripts. Here, the statistician exploits the human failing of making errors while copying from a given manuscript. Thus, although the manuscripts are all of the same original work, they differ in errors and possible alterations made while copying. An error in a manuscript is propagated to all its descendants and two copies made from the same manuscript have more common errors than those copied from different manuscripts. Using the number of common errors between each pair of manuscripts as the only basic data, it has been possible to work out the entire linkage of the manuscripts.

By studying the similarities between the Indo-European languages (consisting of such diverse languages as of Latin and Sanskrit origin, Germanic, Slavic, Baltic, Iranian, Celtic, etc), linguistics has discovered a common ancestor which is believed to have been spoken about 4,500 years ago. And if there is a common ancestor, there must also be an evolutionary tree of the languages branching off at different points of time. Is it possible to construct such a language tree similar to the evolutionary tree of life constructed by the biologists? This is, indeed, an exciting and challenging problem, and the scientific study of such problems is called "Glottochronology". Using a vast amount of information on similarities between languages and a complicated reasoning, linguists were able to identify some major branches of languages, but the exact relationships between them and the times of separation could not be well established. However, a purely statistical approac this problem using much less infor tion has given very encouraging res

A first step in such a study is comparison of words belonging different languages for a basic se meanings such as eye, hand, mot one, . . . and so on. Words with same meaning belonging to different languages are scored with sign if they are cognate and — otherwise. Thus a comparison of languages is expressed as a seque of + and — signs or a vector of form (+ — + + . . .). If there n languages, there are $n(n-1$ such vectors. Using this informat only, Swadesh (*Proceedings of American Philosophical Society*, **96**, 452–463) suggested a method estimating the time of separat between two languages. Once times of separation of all pairs languages are known, it is easy construct an evolutionary tree. T whole task is simplified and ma routine by suitable computer p grams designed to print out whole evolutionary tree by feeding the comparison vectors of + and signs. The method was recently a plied to construct evolutionary tr of the Indo-European languages usi a list of 200 meanings and Malay Polynesian languages using a list 196 meanings (Kruskal, Dyen a Black, *Mathematics in the Archaeologi and Historical Sciences*, 1971, 360–380).

In the application of statistics literature, such as dating of Shak speare's works, chronology of Plat works, linkage of manuscripts, e one may question the validity the results (or the method employe The logical issues involved are t same as when you ask the questio how good are Paraxin tablets for particular patient for curing typhoid fever? The only justificati is that these tablets helped ma typhoid patients before. (But cou they not be fatal to a particul patient?) In the same way, the validi of a statistical method is establish by what is called a "performan test". A proposed method is first us to predict in some known cases a the method is accepted only when performance is found to be sati factory. Of course, one should alwa look for independent historical a other evidences, if available, to corr borate the statistical findings.

Right- and left-handed palm tree



Statistics to detect fakes

Since the acceptan ce of a theory depends on its verifica tion by observed data, a scientist ma be tempted to 'fudge' data to fit

TABLE 3. CHARACTERISTICS AND DISCRIMINANT SCORES

Name of the Play	x (1)	y (2)	z (3)	w (4)	discriminant scores (5)	(6)	(7)
Henry VI, 2	332	13	270	3162	·66	1·18	1·74
Henry VI, 3	366	8	340	2904	·49	·88	1·55
Henry VI, 1	191	17	233	2677	·81	1·18	2·00
Richard III	638	·66	423	3619	1·38	1·99	2·16
Comedy of Errors	198	8	171	1777	·65	·92	1·27
Titus Andronicus	200	17	303	2523	·83	1·06	2·11
Taming of the Shrew	208	21	194	1443	1·12	1·30	1·64
Two Gentlemen of Verona	269	43	174	2292	1·32	1·75	1·96
Love's Labour's Lost	26	11	79	2785	·57	1·06	1·87
Romeo and Juliet	168	71	496	3050	1·31	1·35	3·43
Richard II	258	34	293	2757	1·11	1·46	2·30
Midsummer Night's Dream	59	28	131	2174	1·08	1·39	2·17
King John	151	64	357	2570	1·37	1·50	2·96
Merchant of Venice	325	79	369	2658	1·51	1·77	2·66
Henry IV, 1	92	43	235	3176	1·09	1·49	2·78
Henry IV, 2	221	43	208	3446	1·10	1·69	2·46
Much Ado About Nothing	145	35	126	2825	1·10	1·62	2·20
Henry V	3363	31	219	3381	1·02	1·65	2·03
Julius Caesar	410	129	137	2477	1·77	1·96	2·78
As You Like It	23	34	177	2856	1·11	1·62	2·10
Twelfth Night	167	44	161	2690	1·23	1·68	2·30
Hamlet	528	194	552	3929	1·73	2·14	3·31
Merry Wives of Windsor	54	9	41	3018	·46	1·08	1·67
Troilus and Cressida	463	133	439	3496	1·64	2·07	2·92
All's Well that Ends Well	349	138	316	2966	1·72	2·14	2·79
Measure for Measure	377	148	398	2820	1·77	2·06	2·92
Othello	679	268	694	3316	2·00	2·18	3·27
King Lear	580	243	691	3328	1·92	2·04	3·48
Macbeth	420	246	494	2106	2·11	2·14	3·09
Antony and Cleopatra	666	470	935	3059	2·24	2·00	4·09
Coriolanus	710	394	749	3406	2·16	2·30	3·52
Timon of Athens	334	145	404	2374	1·82	1·97	2·92
Cymbeline	799	393	1027	3339	2·15	1·93	3·98
Winter's Tale	675	330	699	3074	2·13	2·25	3·33
The Tempest	472	227	481	2062	2·10	2·18	2·88
Henry VIII	374	179	437	1167	2·12	2·00	2·69

x = redundant final syllables
y = full split lines
z = unsplit lines with pauses
w = total number of speech lines

theory and claim acceptance of his ideas. Besides being unethical, such a practice does considerable harm to science. No doubt, if a theory is wrong, it will be discovered sooner or later. However, there is a possibility of considerable harm to society by its acceptance meanwhile. A recent example is the 'IQ Fraud' (SCIENCE TODAY, December 1976, p. 33) involving Cyril Burt, the undisputed 'father of British educational psychology'. His theory that differences in intelligence are largely inherited and not influenced by social factors, apparently supported by faked data, influenced political thinking on education of children in a wrong direction.

Does the statistical repertoire include methods to detect whether the data used by a scientist are genuine or faked? Haldane pointed out in "The faking of genetical results" (*Eureka*, **6**, pp. 21–24): "Man is an orderly animal. He cannot imitate the disorder of nature." Based on this limitation of the human brain, statisticians have evolved techniques to detect faked data.

Some of the great scientists fudged data in their anxiety to advance theories about whose validity they were convinced. According to R. S. Westfall (*Science*, **179**, 1973, pp. 751–758), Newton was a master at manipulating observations so that they exactly fitted his calculations in the *Principia*. He quotes three specific examples. To establish that acceleration of gravity at the Earth's surface is equal to the centripetal acceleration of the Moon in its orbit, Newton calculated the former as 15 ft 1 in $1\ ^{7}/_{9}$ lines and the latter as 15 ft 1 in $1\ ^{1}/_{2}$ lines (1 line = $^{1}/_{12}$ inch) giving a precision of 1 part in 3,000 for the comparison. The velocity of sound was estimated to be 1,142 ft per second which has a precision of 1 part in 1,000. Newton computed the precession of the equinoxes to be $50^{ii}\ 01^{iii}\ 12^{iv}$, which has a precision of 1 part in 3,000. Such a high degree of precision was unheard of with observational techniques existing in Newton's times.

In a remarkable study, the famous statistician R. A. Fisher (*Annals of Science*, **1**, 1936, pp. 115–137) examined the experimental data on which Mendel advanced the basic laws of inheritance. In most of Mendel's experiments, it was found that observed ratios of phenotypes were very close to Mendel's predictions. For instance, if you toss a coin 100 times, there is some chance of your getting 50 heads or close to it. But if you claim such a good result on most of the occasions, it arouses suspicion. Fisher showed that the precision of Mendel's data (in showing agreement with his theory) was of a strikingly high order, which can be expected only about seven times in 100,000 trials. He commented on this rare chance: "Although no explanation can be expected to be satisfactory, it remains the possibility among others that Mendel was deceived by some assistant who knew too well what was expected. This possibility is supported by independent evidence that the data of most, if not all, of the experiments have been falsified so as to agree closely with Mendel's expectations."

While faking data is unethical, using wrong data to advance a theory is unscientific. A scientist should, therefore, take necessary precautions against unconscious errors in recording experimental data and uncritical acceptance of data collected by others.

There are also numerous instances of the data and results of statistical analysis being wrongly interpreted. A recent example is the controversy whether the observed difference between the IQ distributions of blacks and whites in the US is due to genetic differences in intelligence. The distribution of IQ of 1,800 black school children had a mean which was 21·1 points less than that of the 'normative' sample of white children. The standard deviation of the distribution among blacks was 12·4, which is about 25 per cent less than the corresponding figure of 16·4 for the whites. Other studies have also indicated consistent differences of the order of 10 to 20 points in the mean IQ of blacks and whites. The results are,

"I think you are right, they were written in that order, the fungus has attacked the commas only."

STATISTICS IN ANCIENT INDIA

There is an interesting reference to the method of estimation by sampling in the *Mahabharata*. Nala was driving King Rituparna to Damayanti's *swayamwara* in a chariot. While Nala was boasting of his knowledge of horses, Rituparna wanted to show off his proficiency in calculation. And while the chariot was speeding past a tree, Rituparna said, " The leaves and fruits of this tree that are lying on the ground respectively exceed those that are on it by one hundred and one. The two branches of the tree have fifty millions of leaves, and two thousand ninety-five fruits ". Nala doubted these estimates and wanted to cut down the tree and count the leaves and fruits. But the king discouraged him, as he was in a hurry to be at the *swayamwara*. As Nala insisted, the king revealed the sampling method which is quicker; he told Nala to count the leaves and fruits on a portion of the branch. Nala cut the branch and was struck with amazement when he found the number of fruits to be what the king had said.

The enumeration of people and the collection of information about the resources of a country must have been practised from the earliest times. The Egyptians, the Babylonians and the Romans preserved records of the resources of the State.

In India, we have clear evidence that administrative statistics had reached a high state of organisation before 300 BC. In the *Arthasastra of Kautilya* (translated by R. Shamasastry, 1915, Mysore Government Press, Bangalore, Ch. XXXV, pp. 178–79), written between 321 and 300 BC, it is enjoined that villages shall be brought " under one or another of the following heads: villages which are exempted from taxation (*pariháraka*), those that supply soldiers (*áyudhiya*), those that pay their taxes in the form of grain, cattle, gold (*hiranya*), or raw material (*kupya*), and those that supply free labour (*vishti*), and dairy produce in lieu of taxes (*karapratikara*)". And among the duties of the Gopa, the village accountant, it is distinctly mentioned that " by setting up boundaries to villages, by numbering plots of grounds as cultivated, uncultivated, plains, wet lands, gardens, vegetable gardens, fences (*váta*), forests, altars, temples of gods, irrigation works, cremation grounds, feeding houses (*sattra*), places where water is freely supplied to travellers (*prapá*), places of pilgrimage, pasture grounds and roads, and thereby fixing the boundaries of various villages, of fields, of forests, and of roads, he shall register gifts, sales, charities, and remission of taxes regarding fields."

It also states that: "Also having numbered the houses as taxpaying or non-taxpaying, he shall not only register the total number of inhabitants of all the four castes in each village, but also keep an account of the exact number of cultivators, cow-herds, merchants, artisans, labourers, slaves, and biped and quadruped animals, fixing at the same time the amount of gold, free labour, toll, and fines that can be collected from it (each house)."

There are numerous references to detailed statistics of various kinds in inscriptions as well as in technical treatises of the classic period of Sanskrit culture. In more recent times, under the Muslim rulers of India, we find descriptive statistics occupying a very important place. The best-known compilation of this period is the *Ain-e-Akbari*, the great administrative and statistical survey of India under Emperor Akbar which was completed by his minister Abul Fazl in AD 1596–97. It contains a wealth of information regarding an empire " faithfully and minutely recorded in their smallest detail, with such an array of facts illustrative of its extent, resources, condition, population, industry, and wealth as the abundant material from official sources could furnish ". To take a random selection, it gives the area, revenue valuation, strength of army and other details for about 15 *subahs* (provinces) comprising over 130 *sarkars* (districts) and over 3,000 *mahals* (townships and sub-divisions) extending from Assam and Arakan to Afghanistan. It also gives the average yield of 31 crops for three different classes of land; annual records of rates based on the yield and price of 50 crops in seven *subahs* (provinces) extending over 19 years (AD 1560–61 to 1578–79); daily wages of men employed in the army and the navy, labourers of all kinds, workers in stables, etc; average prices of 44 kinds of grains and cereals, 38 vegetables, 21 meats and games, 8 milk produce, oils and sugars, 16 spices, 34 pickles, 92 fruits, 34 perfumes, 24 brocades, 39 silks, 30 cotton cloths, 26 woollen stuffs, 77 weapons and accessories, 12 falcons, elephants, horses, camels, bulls and cows, deer, precious stones, 30 building materials; weights of 72 kinds of wood, etc.

C. R. R.

no doubt, statistically significant. But are the differences genetically determined?

The question cannot be answered in definite terms in view of the intrinsic errors in IQ measurement and differences due to cultural and environmental factors. For instance, it has been reported that the IQ of blacks tested by blacks was at least 2 to 3 points higher than when the same persons were tested by whites, which indicates possible intrinsic errors in IQ measurement. It has been shown in one study that fortifying the diet of pregnant mothers from lower socio-economic groups with vitamin B and iron increased the average IQ of their children by 5 points, and at 4 years of age, by 8 points. Thus, factors other than genetic seem to influence IQ. We do not have the type of data large enough to provide quantitative estimates of effects of non-genetic factors. Thus, how much of the observed difference in IQ is attributable to genetic factors cannot be ascertained at this stage.

Ubiquity of statistics

We have seen how statistics plays a vital role in diverse fields of enquiry — from basic research to practical decision-making. Its ubiquity stems from the scientific system developed by the statisticians for " the collection, organisation, analysis, interpretation and presentation of information which can be stated in a numerical form ". The demand for quantitative methods of research has made the use of statistics indispensable specially in soft sciences like economics, psychology and sociology.

The benefits resulting from applications of statistics in industry and management are well known (see p. 37). In manufacturing plants where modern statistical methods are used, production has increased from 10 per cent to 100 per cent, without further investment and without expansion of plant. Thus statistical knowledge is a *natural resource*. Statistics can play a vital role in conducting nation affairs (see p. 40), and a governme can provide best benefits to the peop if it takes policy decisions on the bas of a sound statistical study of proble rather than on the advice of ' committee of experts '. The mo advanced a country is, the better its statistical system and utilisation statistics. In fact, the scope of statisti seems to be unlimited so long as th quest for new knowledge continue to understand nature and to improv the efficiency of human efforts.

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STATISTICS INFORMATION AND INDUSTRY

JAGJIT SINGH

If science is the pursuit of knowledge for its own sake and technology its application to improve the human estate, then tistics is that maid-of-all-work of th which continually purifies raw owledge into its two components — eful information and the distracting ise with which knowledge is in-itably contaminated. Why? Because this world of perpetual flux, we nnot repeat any experiment under entical conditions. Every measure-ent is subject to the influence of numerable uncontrollable disturb-g factors. Even if nothing else anges, the time and place of any peat performance will never be the me. As a result, repeated measure-ents of any physical phenomenon, en the position of such a seemingly nchanging entity as a star, yield fferent results. Indeed, every physi-l measurement or observation we ake is inexorably vitiated by what is lled " experimental error ".

The " error " is rectified by com-uting the average (O) of several bservations $O_1, O_2, O_3, \ldots, O_n$, n the one hand, and their standard eviation (s) on the other. The aver-ge O is then taken as the true value f its position and a specified multiple, sually 2 or 3, of s is a measure of the ccompanying experimental " error ". his is merely to say that, in the above xample, the true value of the stellar osition may be anywhere within the ange $O \pm 2s$; it " errs ", that is, vanders irregularly in the interval $O - 2s, O + 2s$), if we use the word ot in its present-day meaning, but ather in its original, though now rchaic, sense. The average O then is he " *signal* " and the wandering or rring range of $2s$ on either side of O the " noise ". A more precise nethod of measurement, which re-luces the range of the error, will mprove what may be called the signal-to-noise ratio of the experiment; a cruder method will reduce this ratio.

Simple to formulate, the signal versus noise concept is quite general, sometimes surprisingly so. Indeed, any reliable measurement will entail a number of repeated observations (the statistical sample) followed by an analysis of the results more or less along the preceding lines. This is how the signal (information) is separated from the noise, experimental error, etc.

The knowledge that the management of an industrial enterprise gathers to guide its action is no exception to this universal rule. The knowledge is often derived from sample surveys, experimental replications, trial runs and sets of observations made from time to time. Since different samples, replications, trial runs and observations produce different results, it becomes necessary to decide which part of variation among the results observed is due to potentially identifiable causes and which part fortuitous. What then must we do to disentangle such fortuitous and uncontrollable variation as sampling fluctuation or experimental error from real differences that might arise from naturally occurring or deliberately imposed changes in environmental experimental conditions? The short answer is that we must segregate total variation into two components: the fortuitous and the systematic. The former is called " noise " and the latter the " signal ".

Suppose we were in charge of a manufacturing process producing millions of articles. We would naturally want to know what proportion of the articles produced was defective. One method of ascertaining it would be to test all the articles produced in the past and to compute the fraction that is defective. But it would be impracticable to do so. Not only is the number of articles to be tested too large, but in many cases the test may involve destruction of the article to be tested, as, for example, in testing the tensile strength of steel bars or the life-span of an electric bulb. We can, therefore, only 'estimate' the characteristic of our 'population' (in this case, the proportion of defectives among the entire output of the manufactured product taken as a whole) by observing a few specimen samples. But as each sample will yield a different value of the proportion of defectives we have to decide which of these diverse values, if any, is the real defective fraction.

Though the measured fraction of defectives will always vary from one sample to another, there are variations and variations. Some variations may arise due to chaotic conditions prevailing in the production process. Others may arise even if the production process is under as nearly perfect control as possible. For, even if the production matrix is perfectly stable, it will still be subject to random variations which occur in what is called a constant-cause system. The results produced by a constant-cause system also vary and the variation may be narrow or wide. But they lie within the limits prescribed by the standard deviation computed from the observed results. That is, despite the variation, they exhibit a degree of stability. What is stable is not the value of the observed parameter, like fraction defectives in any particular sample, but the distribution pattern of the defectives within the aggregate results. That is, they all lie within certain calculable limits. If any fresh sample yields a value of fraction defectives outside these limits, it is a signal or rather an alarm that the constant-cause system is no longer constant and chaos is beginning to creep in.

Knowing the " noise " level of a production process enables us to sort out all samples into two mutually exclusive categories, according as their fraction defectives fall within or without the " noise " level range of variation. The former may be called conformists and the latter deviants. Deviant samples whose values of fraction defectives fall outside the " noise " level indicate *significant* departure from the constant-cause system, believed to be at work till the appearance of deviants on the production belt. By thus providing a simple criterion which segregates the deviant from the conformist, it enables us to decide when a constant-cause system at work in a production process undergoes a structural change. This is the basis of the essential tool in statistical quality control called " Shewhart control charts". By defining the limits of variation within the stable constant-cause system governing a production process, the Shewhart technique enables us to separate out the assignable causes of quality variation from those which are merely the outcome of inevitable chance. This makes possible the diagnosis and correction of many production troubles and reduction of spoilage and rework. Moreover, by identifying certain of the quality variations as inevitable chance fluctuations of the constant-cause system at work, it tells us to leave a production process alone so long as the variation obtained remains within that " noise-level " range.

Evolutionary operation

A recent development in statistical applications to industry, however, actually requires the deliberate disturbance of the constant-cause system in order to further improve industrial productivity. This novel technique is called by its author George E. P. Box, Evolutionary Operation, or EVOP, for short. The basic philosophy of his approach is that the usual way of operating an industrial plant is nearly always inefficient because it is exclusively preoccupied with the manufacture of a product but not at all with information needed to further improve the process. And yet, with only a slight additional effort, it could easily do both. It could generate the product plus information on how to further increase the productivity of the process.

The technique was originally evolved in the manufacture of chemicals. Within a decade of its adoption, it is now common to find chemical plants improving their production rates to two or three times those originally thought possible, and with a product of greatly improved quality. Although the technique originated in chemical plants, it is *mutatis mutandis* equally applicable to other industries like steel, aeronautics, glass and ceramics, etc. But how does an industrial plant generate the information with which it improves performance while engaged in routine production of a product? The short answer is that it does so by continuing to " tune " the production process even after it has reached its supposedly optimal level after start-up.

Suppose, for the sake of definiteness, we have a new or a newly renovated plant that has just started operation. It is not likely that the yield will be optimal right at commissioning. There will intervene a shorter or longer period of so-called " teething troubles ", during which the plant engineers gradually discover empirically, by trial and error, the right operating conditions. This is the " tuning " process mentioned in the preceding para. Besides the recording and examination of routine plant data, it requires further special studies. These are often carried out in the laboratory, on the pilot plant as well as full plant scale by the research and development staff. Such investigations, particularly when aided by powerful tools of statistical design and analysis currently available (see *Statistical Methods in Research and Production* by O. L. Davies and others) are extremely rewarding. But once they have helped discover the optimal operating process, the operation is apt to become an established undeviating routine. It embodies the best conditions of operation known *at the time*. The manufacturing procedure, in which the plant operator always aims at reproducing exactly the same set of conditions, may be called the *static* operation.

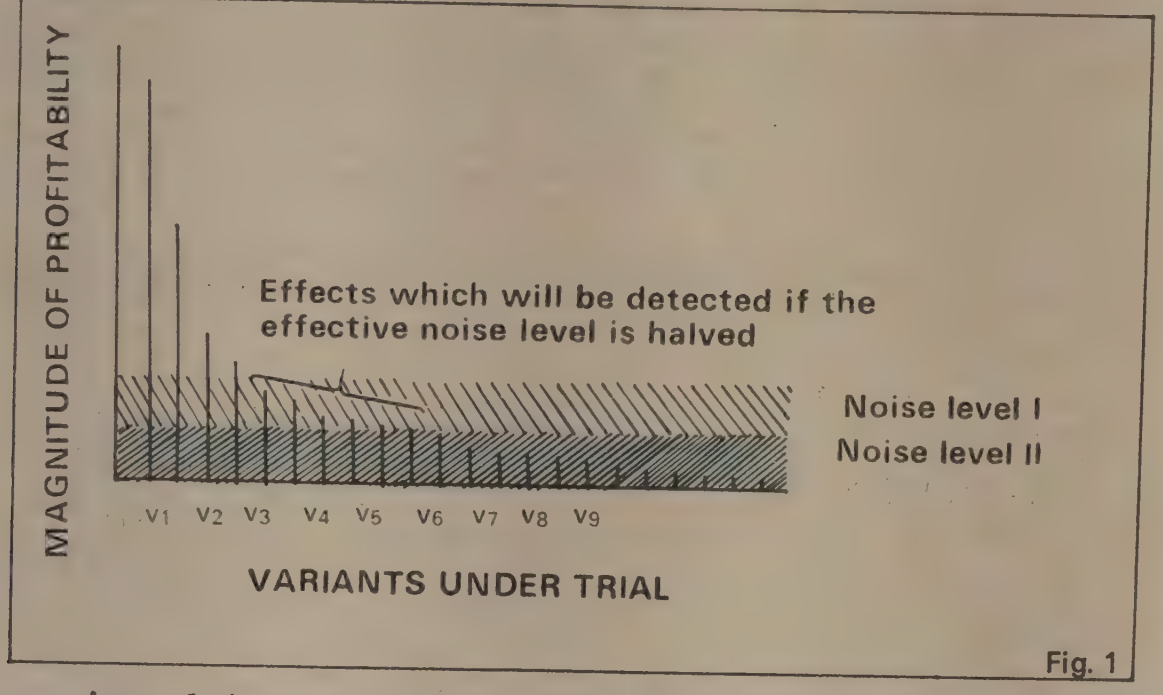

Fig. 1

This static operation is the outcome of the " tuning " process. " Tuning " ends once the static operation routine has been established. Evolutionary Operation (EVOP), however, simply continues the " tuning ", now through the operating staff alone unaided by R & D. It does so because it assumes that further improvements in static operation of the works process are always possible. Process innovation is not a once-for-all discovery. It can and must continually be sought by the operating staff while running the plant normally. This it does by initiating a carefully planned cycle of *minor* variants on the normal works process. Each of the variants is run in turn and continually repeated. Persistent repetition allows evidence concerning the yield and physical parameters of the product in the immediate vicinity of the works process to accumulate during routine manufacture. The stream of information concerning the products from the various manufacturing conditions is summarised and continuously updated. T formation is recorded in such that the works superintendent any time see what weight of ev exists for moving the centre scheme of variants to some new and what types of change are u able and should, therefore, be av Like any other information gat process, EVOP too is subject signal-noise tug of war. But EVOP is dynamical, involvin comparison of data, the inform requirements are correspon more stringent.

Efficiency index

The core pro then is how to discriminate the able variants from undesirable To solve it, we first measure on suitable scale the profitability, quality or some other *efficiency ind* the normal operating routine. We find that even if the operating ro remains the same, the efficiency i differs from one run to another. is because of variability of raw m ials, inability to maintain prec the input variables like tempera pressure, concentration, etc, at assigned levels as well as instrum and measurement errors. The va of the index obtained during a s of runs will, therefore, hover arc their average within a range, dep ing on the standard deviation (s the observations. All variants of normal operating routine with *same* error-spread or noise level say, $2s$ or less, make no differenc the normal operating routine so fa the final output is concerned. They the " null effect " variants with wh the more effective ones are compa This is done by rank-ordering imagination) all possible varia V_1, V_2, V_3, V_4 . . . . of the nor plant routine in descending orde their relative merit. If now their pective efficiency indices be deno as I_1, I_2, I_3, I_4 . . . , and they exhibited in a diagram, we may f some such pattern as is shown in Fig

The figure shows that discernm of effectiveness can be made for o those variants whose efficiency ind I exceeds the noise level of the norm operating routine. George Box ca the noise level of the normal oper ing routine the " height of the grass If it is too high, it will hide the qua we are hunting. It has, therefore, be trimmed low to see the animal pursue. In other words, if a varia such as a change in temperature pr duces an effect in the response whi greatly exceeds the noise level (as, f example, is the case with V_1, V_2, V_3, in Fig. 1), it " sticks out of the grass and can readily be exploited. But

effect produced is smaller than the se level (as is the case with V_8), it ikely to be drowned in the din and ll not be audible. Obviously, to ar a signal in the din of ambient ise, we must improve the signal-to-ise ratio of our operation. We can so either by reducing the effective ise-level, that is, by a tighter pro-ss control, or increasing the loudness the signal, that is, discovering a ore rewarding improvement.

In EVOP, we do both. The loud-ss of the signal is increased by liberately introducing carefully osen changes in the variables under udy. The effective noise level is duced by repetition of the changes id using averages of the results ecause the standard deviation of mple means is always much lower an that of the individual observa-ons included in the sample. Fig. 1 ows how a number of effects pre-ously masked, like V_5, V_6, V_7, are own up, if we cut the noise level to ne-half of its previous value.

nplementing any EVOP programme

Unfortunately, to nprove the signal-to-noise ratio in ny real-life situation is not as simple s this account might seem to suggest. he practical difficulties in imple-enting any EVOP programme are vo-fold. First, it is not easy to devise n overall index of total *efficiency* of ne process routine under study. The eason is that efficiency has multiple spects, some of them running counter one another. An improvement in uality, for instance, may increase the ost so that the evaluation of the trade-ff, cost versus quality, becomes a roblem. We solve the difficulty by electing a *single* but simple criterion hich can be easily measured with a igh degree of accuracy such as ield, or consumption coefficients of naterials and the like. But fixing a neasurable performance criterion is nly a minor prelude to our main nvestigation, namely the study of its ehaviour under the impact of diverse ariants of the normal operating outine. This behaviour may be tudied in three different ways. And ach of them bristles with its own difficulties.

Consider, to start with, the first, alled " the one-at-a-time-method ". Here we modify only one variable at time *ceteris paribus* until the best esponse is obtained. Then a second ariable is modified, and so on, until ll controllable variables have been nodified. It often happens that when we are examining some later variables t becomes necessary to return to the earlier ones to confirm or deny their

"Another enterprising variable, it looks like"

optimality in the light of later results. Such a back-and-forth zigzag procedure inevitably requires a lot of trials to cover most processes. Even so, it cannot be guaranteed to locate the optimum.

The way out is to resort to the second, the so-called " grid-method ". It studies the *simultaneous* impact of varying two or more factors like temperature, pressure, concentration, etc at the same time. Though the factors mentioned are continuous variables, in actual practice only a few discrete values of these variables are relevant to the operation under study. Suppose, for instance, temperature (T) can take only one of the two values, T_1 or T_2, and concentration (C) either C_1 or C_2. There are then only four (2^2) possible alternatives — T_1C_1, T_1C_2, T_2C_1, and T_2C_2 to explore. It is easy to see that with an additional factor P also operating at two levels there are only eight (2^3) possible alternatives as listed below:

$T_1C_1P_1$, $T_1C_2P_1$, $T_2C_1P_1$, $T_2C_2P_1$,
$T_1C_1P_2$, $T_1C_2P_2$, $T_2C_1P_2$, $T_2C_2P_2$

In general, if we have n factors, each operating at m levels instead of only two, the number of possible alternatives to explore proliferates exponentially. Since each of the m levels of a factor can be combined independently with the same number of levels of another factor, it is not difficult to see that the number of possible alternatives is $m \times m \times m \times \ldots$ (n times), or, m^n. In actual practice, we have, of course, to make do with several levels of each of the many variable factors. It is, therefore, inevitable that we have to employ in any realistic application much more complex designs of the type m^n rather than the simplistic 2^2 or 2^3 plans of our illustration. All possible alternatives included in the factorial design are tried and their outcomes compared. The method is, no doubt, likely to lead to the optimum, but it often demands a colossal amount of trial and experimentation to cover all possible alternatives envisaged in the factorial design.

Since both dealing with one factor at a time as well as several simultaneously lead to a blind alley, it is usual to resort to a compromise of the two. It is called the " determination of optimum conditions ". It attempts to locate them with minimum experimental effort. There are several such ' short-cut ' techniques, some of which are based on fairly sophisticated mathematical theories. A detailed discussion is beyond the scope of this article. As before, the object of each of these methods is to obtain the optimum levels of input variables (like temperature, concentration, time of reaction, etc) as quickly as possible with least effort. They may be described as least effort ways of finding the optimum. The interested reader is referred to George Box's book for a fuller exposition.

However, no matter how complicated the actual implementation of the technique, its core idea as well as basic objective is not only simple but instantly credible. For EVOP is merely the introduction of carefully planned, deliberate mutations in the works process routine and testing them under fullscale plant operation for permanent incorporation in the plant's operating routine or outright rejection, according as they seem to " work " or not in actual practice. The procedure is not unlike biological evolution which advances life by natural selection sorting out random genetic mutations for propagation or extinction. This is how biological evolution conjured life out of its inanimate slumber and then piloted it all the way from its humble origin as a ' subvital ' autocatalytic particle of protein or nucleic acid to man as an increasingly complex crescendo of self-sustained patterns of chemical reactions. If its culmination has taken billions of years to arrive, it is because genetic mutations (unlike those of EVOP) arise by chance and are not specially contrived by design. This is why EVOP is a miniature but vastly accelerated version of that grand orchestration of nature which, to borrow the graphic description of Jacques Monod, " draws alone and unaided all the music of the biosphere from a source of noise ".

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STATISTICS IN NATIONAL PLANNING

V. M. DANDEKAR

Statistics are facts collected, collated and tabulated. They are needed for an intelligent appraisal of what has happened in the past and for planning for the future. Some of them accumulate routinely in the process of public administration. Such, for instance, are statistics of governmental revenue and expenditure which accumulate in the finance ministries of the Central and State governments, of currency and banking which accumulate in the Reserve Bank of India, of exports and imports which accumulate first with the Customs and then with the Ministry of Trade, of education which accumulate with the education ministries, or of employment which accumulate with the Directorate of Employment and Training.

A major problem with these statistics is that they are collected as part of the administration, in several hundred subordinate offices of the government. For them to be collated and aggregated at the state and national levels, it is necessary to ensure that they are collected with uniformly understood definitions and concepts. This is more difficult than it seems and requires continuous communication between relevant agencies. One of the major functions of the Central Statistical Organisation (CSO) is to facilitate such communication and ensure uniform definitions and standards in statistical collections. It also sees to the speedy and meaningful collation and aggregation at various levels.

Guidance to policy-makers

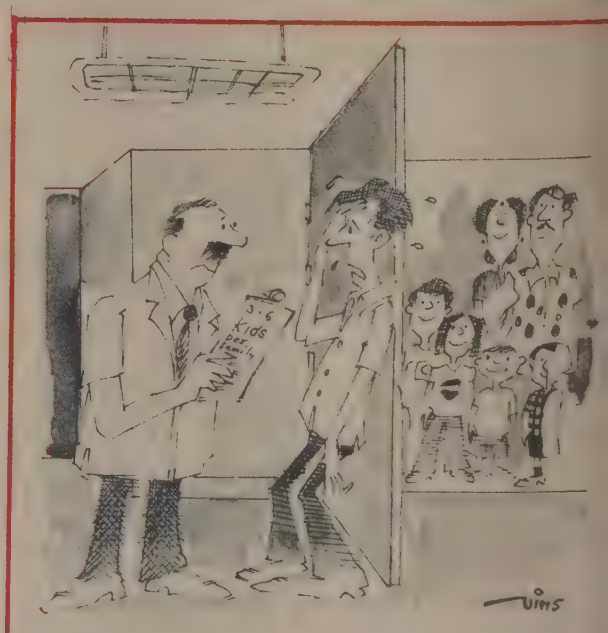
Such statistics, when intelligently read and interpreted, provide useful guidance to making policies and formulating programmes. But it is unfortunate that policy-makers, in the political as well as administrative wings of the government, are often too busy with immediate problems of the day; they have little time to look back into the past experience recorded in these statistics. Consequently, only a fraction of the experience that accumulates is ever used to guide future policies and programmes. A major responsibility rests with the statisticians working in government departments. They must continue to analyse the statistics as they accumulate and interpret them to policy-makers in terms in which the latter think. Policy-makers have their sights quite rightly fixed on the future; but someone must keep them intelligently informed of what happened in the past. That is the primary function of the statistics which routinely accumulate in the administration.

There are statistics which do not accumulate routinely in the administration but are collected deliberately because we need them. Such, for instance, are statistics pertaining to industries which are collected in the Annual Survey of Industries (ASI). The premier national agency for collection of statistics, when they must be collected outside the routine administration, is the National Sample Survey Organisation (NSSO). It has a countrywide field staff for the purpose. The Annual Survey of Industries (ASI) is one of the major operations of the NSSO. It involves collection of elaborate statistical information from over 50,000 industrial units annually. The data collected are tabulated, processed and published by the Central Statistical Organisation annually in a series of volumes.

The ASI focuses on the statistics of production, that is, the output of the several industries and the raw materials, or the inputs, used for these outputs. Such statistics are used to construct what is called an Input-Output Table. The Input-Output Table is one of the major instruments of planning. Suppose we have data on the outputs and inputs of 100 different industries. These data are organised in the Input-Output Table which, in this case, is a matrix with 100 rows and 100 columns — each row and column giving information pertaining to one particular industry. A row shows how the output of an industry is utilised. A part of the output is used up as raw materials, that is, inputs, for its own output and the outputs of several other industries. These are shown in the columns assigned to different industries. The balance of the output is used for consumption or export. This balance is called the final demand for th put of the industry. In distinctio part of its output which is us input is called the inter-ind demand for its output.

Input-output tables in planning

Thus a ro Input-Output Table shows how output of a given industry is partly as inputs for itself and for industry and partly for consum and export. The same informa read columnwise gives the inpu different industries and where come from. As mentioned earlier Input-Output Table is one of essential instruments of plann particularly of planning of pro tion. Imagine, for instance, that decided on the basis of certain rele considerations that the country sh have so many million tonnes of a tional cement by the end of 1 What the Input-Output Table is that in order to produce the a tional cement, so much additi coal and several other things will h to be produced, not because they needed on their own account because they are needed as inputs the production of cement. And produce the additional quantities coal and several other things will turn, require additional inputs several things, and these may incl some cement as well, and so on. short, the production of a cert additional quantity of cement to m an additional final demand for ment, creates inter-industry dema for several commodities, includi cement. The desired additional qua tities of cement cannot, therefore, produced without at the same ti producing these several commodit including some additional ceme needed as input. The Input-Outp Table is an aid to estimating the inp



" Phew! what a hard time I had finding an average Indian family."

ded directly or indirectly to meet additional final demand for, say, tonne of cement. Thus, it ensures t a plan of production is internally sistent in the sense that it takes account the inter-industry demd arising out of production of mmodities to meet given final nands.

An Input-Output Table is useful n in economies in which production ot centrally planned. Consider, for tance, the American economy. ppose the demand for new cars s down as a consequence of a rise gasoline price and the output of automobile industry has to be cut wn. The Input-Output Table ngs out its effects on other indust- which supply inputs to the autobile industry and, in turn, on ier industries linked with these instries, and so on.

A major use of the ASI is to epare such an Input-Output Table. e Survey is conducted annually. ere are other special collections of tistics which, because of the size of operation, cannot be conducted ery year. For instance, the Census Population is conducted once in years and the Census of Livestock ce in five years. The Census of riculture was conducted for the st time in 1971–72 and is proposed be conducted once in five years. Economic Census is being conted for the first time this year, d may later be conducted periodicy, say, every five years. The purse of such censuses is to provide nchmark data on important aggretes and their break-ups. For inance, the Census of Population ovides a count of the population d its break-up by sex and age, imates of labour force and its eak-up by industry and occupation, d information on education and eracy and migration of the populaon between regions and between ral and urban areas. Estimates of ese items for inter-census years are rived by statistical methods of terpolation; projections for future ars are made by appropriate statistil methods. By comparing two censes, birth and death rates are estiated and entire Life Tables are nstructed. Censuses are thus a eriodic stock-taking of several aspects the economy.

terpolation

Because of the normous size of the operation, censes are conducted only periodically, nd estimates for the intervening years are derived by interpolation. There is another way of approaching this problem. Could we conduct a partial census every year and build-up estimates for each year on the basis of this partial census? Under certain circumstances, this is possible; but what we have loosely called a partial census should then properly be called a sample census. Sample surveys are an extension of this principle. Consider the Annual Survey of Industries, for instance. Initially, it was called the Census of Manufacturing Industries. It was a census in the sense that all factories of a certain category registered under the Factories' Act were covered. To keep the operation within manageable limits, only 29 major industries were covered. To cover all the industries would have made the annual exercise unmanageable. But that also meant that no information was available for the other industries. To make up for the lacuna, a Sample Survey of Manufacturing Industries was started wherein all the industries were covered but only a sample of factories of each industry were visited in a given year.

The present ASI rationalises and simplifies these procedures. All the factories registered under the Factories' Act are divided into two categories which we may conveniently call: (*a*) large factories, and (*b*) small factories. The classification is based on whether the factory uses power or not and on the number of workers it employs. There are about 20,000 large factories and 60,000 small factories. The ASI covers all the 20,000 large factories every year, but only one half of the 60,000 small factories in one year, and the other half the next year. The estimates of industrial output etc in any year may be based on the estimate based on the large factories plus double the estimate based on half of the small factories. Alternatively, it may be based on the estimate based on the large factories plus the estimate based on all the small factories covered in two years, the current and the previous; the latter estimate would be appropriate if the annual changes in output are not large, and if they are not systematic.

The method of sample survey is possible if two conditions are met. First, we should know the totality of all the units which would be covered in a complete census; in statistical jargon, we should know the 'population' — the totality which is the object of the study; or we should have the sampling frame as it is often expressed. Second, the sample of units which we actually survey in a year must be a 'random' sample. 'Randomness', a statistical-technical concept, means that the probability, or the chance, of any unit of the 'population' being included in the sample must be equal, or more generally the probability of a given unit being included in the sample must be known. Thus, though we call it a random sample, what, in fact, is random, or has to be random, is the procedure by which the sample is selected. If the procedure is random, the sample is random; otherwise it is not.

It is more difficult than it would appear to devise a procedure of selection that is random. For instance, considering the case of small factories, it will not do merely to leave the matter to the investigator with the instruction to choose half the factories at random. The normal human mind seldom, if ever, operates randomly. It is full of preferences and prejudices, and is conceited enough to believe that it has none. An appropriate procedure has, therefore, to be devised, and in the ultimate analysis, it has to be in the nature of drawing lots to decide whether to include or not include a given unit in the sample.

Estimates of crop acreages

Even where an annual census is possible, and is being done, it is worth examining if it should not be replaced by a sample survey. Take, for instance, the statistics of land utilisation—of areas sown or planted under different crops each year. Presently, in large parts of the country where a land revenue agency exists, the statistics of crop acreages each year are based on a field-by-field inspection by the *patwari* of areas sown under different crops in each sowing season of the year, which are at least two almost everywhere and more in some areas. This is an enormous operation being done annually. Leave alone the field-by-field physical inspection of crops, twice or more often during a year, even the clerical work of recording the crop acreages, field by field, adding them up to get the village totals, and cumulating the village totals to tehsil, district and state totals is enormously laborious and time-consuming. And because of this, the final statistics arrive too late to be useful for immediate policy.

Is such an elaborate census, therefore, worthwhile? Can estimates based on a sample survey not serve the same practical purpose? Could we have estimates of crop acreages which may not be as good as those based on a hundred per cent inspection of all the fields in all the villages, but which will be speedier

Statistics— Convenient & Inconvenient

How is statistics used in socio-economic planning? In general, statistics do not enter the planning process in a concrete and specific manner. They inform the policy-makers on the broad dimensions and relations of several socio-economic parameters.

There are several difficulties in using statistics in planning in India. First is the inadequate socio-economic analysis of the mass of statistics becoming available. Quantitative socio-economic analysis has not kept pace with the collection, collation and presentation of statistics. A branch of economic analysis comprising mathematical economics and econometrics, which should have given the lead in this matter, has unfortunately tended to rest on simplistic notions of causal relations in socio-economic phenomena and has done more harm than good to quantitative socio-economic analysis. Consequently, the socio-economic analysis and implications of the mass of statistics being collected are not presented to policy-makers in terms meaningful to them.

Second, the decision-making processes of the policy-makers are deeply rooted in political considerations; this is fair and right if we interpret the term 'political' liberally, and not in its vulgar connotations. Hence, if certain decisions indicated by statistics and their economic analysis are not judged politically acceptable, the policy-maker often simply questions the reliability or veracity of the statistics; if he is more sophisticated, he asks for more data and more details. Some professional economists and other social scientists, with possibly greater understanding of the political processes, who are members of the group of policy-makers or, at least, close to that group, also often react to statistics in the same manner. And there the matter rests.

Let me illustrate. There are statistics on the difference between yields of agricultural crops with and without certain quantities of chemical fertilisers. How do we expect this information to enter the planning decisions? Shall we say, so much additional fertilisers give so much additional grain output; the country needs so much additional grain output and, hence, the plan should provide for so much additional supply of fertilisers? This would be obviously too simplistic. Several questions arise. The fertiliser results are naturally based on the fertility of lands where fertilisers are used. Can these results be extended and applied to other lands where fertilisers are not presently used? If the results are based on field data, and not on controlled experiments, is it not possible that the fertilisers are
those lands and crops which r
more favourably to them, and t
extension will have to be done
favourable lands and crops?
results are based on controlled
ments, their extension to actu
conditions always raises seriou
blems because of the large dif
between the results under experi
conditions and under field cond

One must also examine wheth
fertiliser results are economicall
ible, and that brings in the ques
future prices, of fertilisers and
inputs and also of the agricu
produce; then the discussion ar
decision-making process become
for all. Then, again, agricultural
sion, even of valid results, takes
simply because education and
sion take time. How much time s
the policy-makers allow for a c
expansion of use of fertilisers?
one must inevitably leave it t
judgement of the administrators-
policy-makers. Finally, fertiliser is
one element in the development
There are innumerable others.
part of the limited resources shou
devoted to expansion of fer
production? In the final analysis
is essentially a political question
must be decided politically.

To sum up, what do our stat
on fertilisers say? They show
fertilisers are useful. They also

and better than guesswork? With this in view, recently a scheme called the 'Timely Reporting Scheme' has been introduced. Here, the *patwaris* are asked to complete crop inspection in a random sample of one-fifth of the totality of villages on a priority basis and report the results before a certain date. The *patwaris* inspect the remaining four-fifths of the villages in the normal course of their work. This they do because the State governments still believe that the estimates based on one-fifth of the villages are provisional, and that the final estimates must be based on crop inspection in one hundred per cent of the villages. This is no more than a habit of mind. It is hoped that, in due course, it will be realised that the estimates based on the crop inspection in one-fifth of the villages are not only received in time but they are good enough to be treated as final. The *patwaris* will be then required to inspect crops in only one-fifth of the villages each year, thus allowing them to attend to several other functions.

Of course, in principle, a census is better than a sample survey. In practice, however, if you have a well-designed sample survey with a large enough sample, the improvement in the accuracy of the estimates to be achieved by a complete census is not often worth the effort and expense. That is the *raison d'etre* of the method of sample survey.

Besides, there are circumstances in which a census is not physically possible. Consider estimates of foodgrain production. Crop production fluctuates from year to year not only because of changes in crop acreages but also because of fluctuations in yields per acre due to differences in weather conditions from year to year. Hence, estimates of foodgrain output have to be built up each year. If this is to be done by a census, information will have to be collected each year from cultivators on the output of different crops in their fields. Though enormous, the task is not necessarily impossible. But there are doubts about how good such estimates would be. In fact, there is general agreement that estimates of agricultural production based on statements of farmers are not likely to be very reliable. For reliable estimates, the crop must be physically harvested, thrashed, dried and weighed by the statistical agency or at least under its supervision. And to do this for the entire cropped area is obviously not possible. Hence, a sample survey is used. A random sample of plots, usually of 5×5 metres is select-
ed and marked, the crop on the sa
plot is cut, threshed and weighed.
loss of weight by driage is estim
independently by similar samp
methods. Thus, estimates of ave
yields per acre of different crops
obtained. These yield estimates m
plied by estimates of areas u
different crops give the estimate
production of different crops.
India, the estimates of production
majority of crops are based on
method commonly called the C
Cutting Experiments. They inv
about 200,000 experiments each y
conducted by appropriate agencie
state governments under the ove
supervision of the National Sam
Survey Organisation.

Can aggregates such as, say,
population number by age and
be estimated by means of a sam
survey? On balance, it seems tha
decennial census is to be preferred
an annual sample survey. Nevert
less, even in a decennial census, o
a few questions can be put to a respo
ent. For instance, in the Indian c
sus, the number of questions
normally 14 or 15. With so
questions, besides the basic classifi
tion by age and sex, only a bro
classification by such attributes
marital status, number of liv

areas and the crops where fertilisers being used. They indicate the ad dimensions of the additional ds. They may also indicate condi- s of economic feasibility of fertiliser All this is not unimportant. But xpect that the statistics on fertilisers decide, by the rule of three, cation of resources to fertilisers in iven plan period would be too plistic.

There are cases where the decisions political and statistics, if they are convenient, are simply set aside, stioned or more statistics are asked Consider, for instance, the policy and redistribution. Statistics of land ribution, collected several times, rly show that redistribution does touch even the fringe of the pro- m of the landless and the small and rginal farmer. But it is a political icy. Consider again the problem of burden of cattle on land. Statistics lected quinquennially clearly show t the uncontrolled growth of the tle population has resulted in an duly large cattle population of erior quality. But the cow is sacred. ally, consider the problem of un- ployment and under-employment. ere are now enough statistics to icate the broad dimensions and the ure of the problem. But, because the political unwillingness to face problem, more data are asked for.

V.M.D.

ildren, education, industry, occupa- n and migration can be attempted. e census cannot take more ques- ns either on items such as income, penditure, employment and un- ployment or questions in greater pth such as on fertility, migration d schooling, as distinct from literacy d education. For such comprehen- e and in depth enquiries, recourse ust be taken to the method of mple survey. An increasing volume sample survey data is now becoming ailable both through official and n-official agencies.

ational Sample Survey rganisation

The National Sample rvey Organisation (NSSO) has ree main wings: Socio-Economic, dustrial and Agricultural. The In- strial Statistics Wing is mainly sponsible for conducting the Annual rvey of Industries. The Agricultural atistics Wing supervises the collec- on of area and yield statistics State government agencies. The cio-Economic Wing is engaged in a ries of annual surveys on various cio-economic questions like in- me, expenditure, employment and nder-employment, landholdings and farm business, irrigation, livestock numbers and its output, non-agricultural enterprises not covered by the ASI, population fertility, mortality and migration, rural electrification, social consumption, building construction, housing, slum conditions, etc. These surveys are based on a country-wide sample of over 150,000 households appropriately drawn from the rural and urban areas.

Multi-stage sampling

We mentioned earlier that, for a sample survey, one must know the totality or the 'population' from which the sample is to be drawn. If one wants to take a sample of factories, one should have a list of all factories, which is possible. Similarly, if one wants to draw a sample of households, one must have a list of all households. At the time of the decennial census of population, a list of households is prepared in the form of what is called the National Register. But the Register becomes outdated soon. And even if the Register were updated every year or even day by day so that an up-to-date list of households was in principle available, in practice it would be physically impossible to handle such lists of households numbering about 150 million in order to draw a sample of about 150,000 households. To circumvent the difficulty, statisticians employ a device which they call multi-stage sampling.

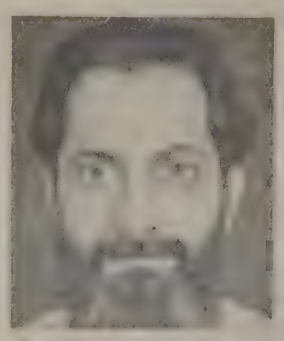
In multi-stage sampling, one does not draw a sample of the desired units directly; one reaches such a sample in stages through samples of intermediate units. The sample of households in the National Sample Survey is drawn by two-stage sampling. For instance, in order to draw the sample of rural households, in the first instance, a sample of villages, about 10,000, is drawn from a list of all villages. In the second stage, the investigators visit the selected villages, make lists of households in each selected village and draw a sample of say 10 households from each village.

The results based on a sample are liable to 'sampling error'. Let us see what it is. Consider the case we have been discussing. We have a sample of 10,000 villages with 10 households from each village, and let us suppose that we are interested in knowing what proportion of the population lies below a certain level of per capita consumer expenditure. We can find this from our sample of 100,000 households. Suppose someone adopts the same method, or we ourselves take a second sample of 10,000 villages with 10 households from each village and find the proportion of the population below a certain level of per capita consumer expenditure. In general, the results from the two samples will be different. The variation in the results based on different samples, all randomly selected, is called the sampling error. Results based on larger samples generally have smaller sampling errors. This is the statistical Law of Large Numbers. But since larger samples also cost more, the size of the sample is decided by a balance of consideration of costs and accuracy needed for practical purposes. One of the concerns of statistical theory is to design a sample, which, for given costs, gives estimates with minimum sampling error.

With the increasing demand for statistics of various socio-economic aspects of the population, the method of sample survey has become inevitable and is being employed increasingly. The method is one of the principal contributions of statistical theory to collection of statistics needed for planning for social and economic development.

But the data must be collected by means of a well-conceived and well-structured questionnaire. For the data to be reliable, attention must be paid to the working conditions of the field investigators and adequate supervision and inspection must be ensured. Finally, for the results to be useful, the collected data must be speedily tabulated and analysed. Computers are now being used increasingly for the purpose.

Statistics is information, and more information leads to greater demand for still more information. As statistical agencies, such as the NSSO, collect and make available more information analysed in greater depth, the policy-maker raises new questions and asks for more information and analysis. This is legitimate and welcome. However, the policy-maker must also learn to use whatever statistics become available before asking for more and not ask for more information merely to postpone urgent policy decisions (see box above).



Prof. Dandekar is Director of the Gokhale Institute of Politics and Economics, Pune. His work (jointly with N. Rath) *Poverty in India*, published in 1971 is acclaimed as a path-breaking study. He is also Chairman of the National Sample Survey Organisation.

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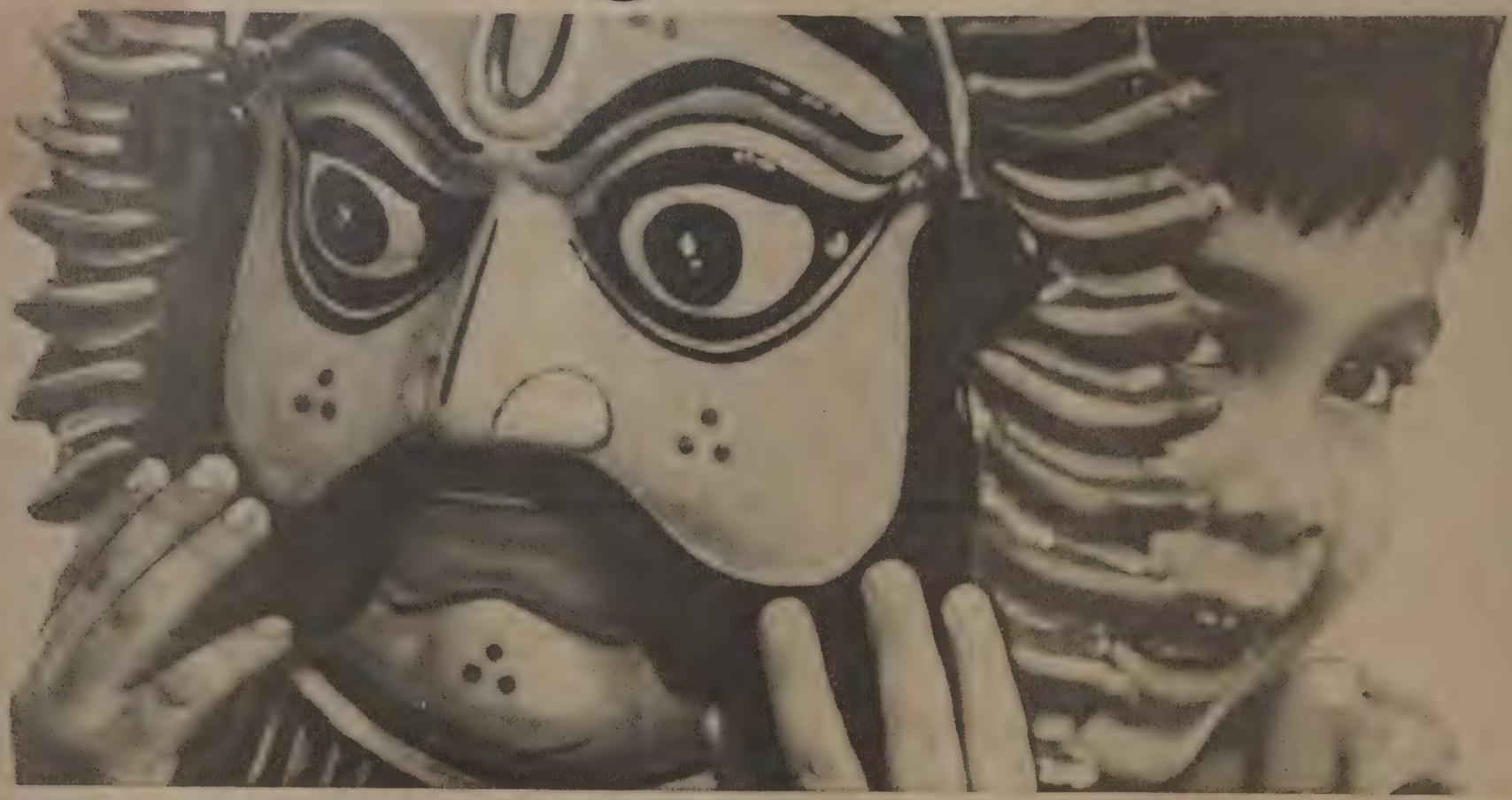

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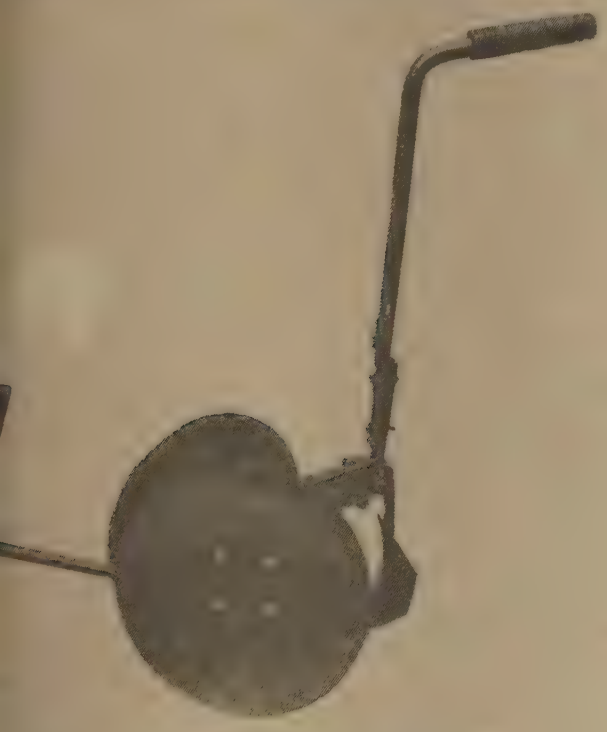
is disc-plough is a me-saver

y using the disc-plough designed by Mr. S. Chandrasekharan of Madras, the farmer can do his ughing in one-fourth of the usual e. This patented agricultural tool, s claimed, can cover one acre of d in 2½ hours — almost the same aken by a power tiller — as against inimum of 10 hours required by a r of bullocks operating a traditional ugh.

The new plough essentially consists two specially designed discs linked ether through a fish-shaped cast n piece and supported on ball rings to ensure frictionless rotation t reduces strain on the bullocks. A lder prevents wobbling during



rudder prevents wobbling during ughing . . .

ughing, and can be adjusted to t the height of the bullocks. Made steel, the whole device weighs out 24 kg, only 10 kg more than ordinary plough. The additional ight will not be a disadvantage to bullocks since the discs are fitted the central portion with ball bear-s for easy frictionless movement. is will reduce the strain on the llocks, and even two small llocks can draw the plough with le effort.

The new plough makes 45–50 cm de, 15–20 cm deep furrows — turn-g the soil, uprooting the grass and xing in the manure — and covers ·5 cm in one rotation of the discs. can be used both on dry lands and t lands.

The disc plough will give trouble-e service for over five years, says r. Chandrasekharan. Maintenance can easily be done by the village blacksmith. Oiling can be done by the farmers by removing the oil cup. At present he is making and selling the plough himself, for Rs. 350 a piece, but would like to link up with an entrepreneur to mass-produce his invention.

BADIUDDIN KHAN

New catalyst for heavy water production

A new water-repellent platinum catalyst, for the production of heavy water by the hydrogen-water chemical exchange process has been developed by the Chalk River Nuclear Laboratories in Ontario, Canada. The new catalyst is claimed to be 1,000 times more active than the best catalyst being used now.

Canada has a high stake in the heavy water technology; its CANDU-type natural uranium nuclear power reactors use heavy water as moderators. And, as in Canada, the first phase of the nuclear power programme in India is also based on CANDU-type reactors (except the Tarapur reactors which use enriched uranium and light water), requiring considerable quantities of heavy water. Accordingly, four heavy water plants, one each at Baroda, Tuticorin, Talcher (Orissa) and Kota are being set up. While the first three plants are based on the NH_3-H_2 exchange process, the heavy water plant at Kota is based on the H_2S-H_2O dual temperature chemical exchange process based on the know-how developed at the Bhabha Atomic Research Centre (BARC), Trombay. This process, though independent, suffers from the disadvantage that it has to handle tons of corrosive and toxic H_2S gas, which demands special care in selecting the material of construction and avoiding environmental pollution. So R&D efforts have been initiated in various laboratories in the world, including the BARC, to develop an alternative process for heavy water production on a large scale.

Some of the processes under consideration are: (1) amine-hydrogen in combination with H_2-H_2O exchange process; (2) ammonia-hydrogen in combination with H_2-H_2O exchange process; and (3) hydrogen-water exchange process (bithermal).

Of these, the hydrogen-water exchange process is simple, non-toxic and pollution-free, and if a suitable catalyst is developed, it could be an attractive alternative to the H_2S-H_2O process for largescale heavy water production. Various catalysts like platinum on activated charcoal and nickel on chromium oxide had been tried in the past without success. The major problem seemed to be a substantial reduction in the activity of the catalyst in the presence of water; water seems to block the hydrogen from the catalyst surface.

Therefore, the application had to be restricted to the gas phase only, where the gas had to be heated at every stage before it entered the catalyst bed to prevent poisoning. Apart from complicating the design, this leads to higher energy consumption and has not been economically feasible. Hence, efforts have been going on in Canada and elsewhere to coat the catalyst with a polymer like Teflon, which will allow only water vapour to pass through, but will restrict the passage of liquid water, consequently avoiding the poisoning of the catalyst.

The Canadian development, reported at a recent American Chemical Society convention (*Chemical & Engineering News*, **55** (24), 1977) indicates that if this catalyst could be successfully used for production of heavy water on commercial scale, a breakthrough would be achieved. In this catalyst, platinum is coated on activated charcoal, and both bonded to water-repellent polymer, Teflon.

The Chalk River group is reported to be developing a combined electrolysis catalytic exchange process for heavy water production, that is, electrolysis followed by the water-hydrogen exchange process, in which the catalyst facilitates the exchange of isotopes while liquid water flows against a stream of hydrogen gas in an exchange column. But since the process releases large quantities of hydrogen as a by-product, it cannot be economically feasible unless integrated with some other industry requiring this hydrogen gas. The process could be independently used if water is used as feed material and hydrogen is circulated in a closed loop through a pair of cold and hot towers as is done in a dual temperature H_2S-H_2O exchange.

P. G. DESHPANDE

[Mr. Deshpande is Deputy Project Director, Heavy Water Project, Department of Atomic Energy, Bombay.]

NOBEL PRIZES

PHYSICS

The Nobel Prize in Physics for 1977 has been awarded to P. W. Anderson, N. F. Mott and J. H. Van Vleck. Anderson and Van Vleck are from the United States and Mott is from England.

John Hasbrook Van Vleck comes from a distinguished family of scientists — his father and grandfather were well-known mathematicians. After obtaining his doctorate from Harvard in 1922, Van Vleck taught at Minnesota, Wisconsin and Harvard, where he was the Hollis Professor of Mathematics and Natural Philosophy and is now Professor Emeritus. He is a great teacher and several famous American physicists have been his students.

Van Vleck is known for his work on magnetism in solids, magnetic resonance and molecular spectra. His first book *Quantum Principles and Line Spectra*, published in 1926, was based on the old quantum theory, and was immediately outdated by the introduction of quantum mechanics. He mastered the new methods and pioneered the application of these methods to study the electrical and magnetic properties of solids. In 1932, he published his classic work, *The Theory of Electric and Magnetic Susceptibilities*.

W. Heisenberg pointed out that the explanation of ferromagnetism was to be sought in the exchange phenomena of electrons. This is a specifically quantum mechanical effect which characterises systems of identical particles. It is a basic postulate of quantum mechanics that systems of identical particles must exist in states which remain unaffected (or take on a negative sign) by an interchange of all the co-ordinates of any two particles. This leads to the appearance of an additional term — the 'exchange energy', when a computation is performed of the energy of such a system. Now any system will tend to exist in a state with minimum energy, and Heisenberg's contention was that for a system of interacting identical magnetic particles like electrons, such a minimum energy state would be achieved when all the magnetic moments were aligned in parallel. P. A. M. Dirac introduced formal mathematical machinery to describe such exchange, but it was Van Vleck who really popularised the Heisenberg model. Many complicated magnetic phenomena could be explained on the basis of this model. Van Vleck also described a simple theory of antiferromagnets first discussed by L. Neel and L. Landau, and discovered a type of temperature-independent paramagnetism (Van Vleck paramagnetism).

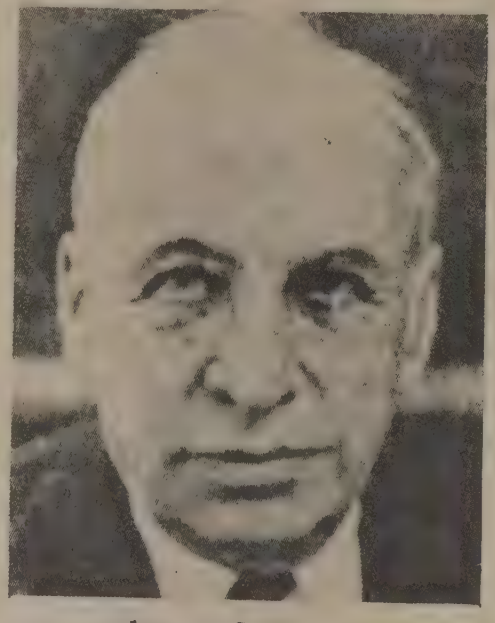
In the course of his work on transition metal and rare earth salts, Van Vleck developed the idea of crystal field, that is, an effective field originating from more-or-less weak covalent bonds (called 'ligands') of magnetic ions with its neighbours. While studying magnetic resonance phenomena, Van Vleck in a series of classic papers (for example, *Physical Review*, **74**, 1948, pp. 1168-83) applied Waller's method of moments to the problem of spin-spin relaxation, calculated the line-shapes, and explained the phenomena of exchange narrowing.

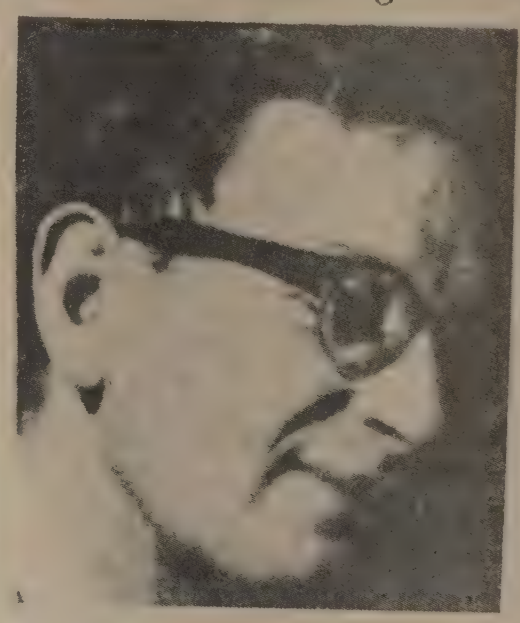
Philip Warren Anderson was a student of Van Vleck. He has been a member of the staff of the Bell Telephone Laboratories, USA, since 1949 when he obtained his PhD from Harvard. Since 1967, he has been a Visiting Professor of Theoretical Physics at the University of Cambridge, spending six months at the University. Now he has switched over to Princeton.

His early work was on spin waves in antiferromagnets and motional narrowing of resonance lines. When the theory of superconductivity was proposed by Bardeen, Cooper and Schrieffer (known as the BCS theory), Anderson developed the equation of motion method to resolve the problem of gauge invariance and collective modes. With P. Morel, he showed how to incorporate the electrostatic 'Coulomb' interactions into th theory. His other contributior minated phase transition in He-3, local magnetic momer alloys, time-reversed pairing ir superconductors, gapless sup ductivity, and Josephson tunn He applied the idea of spontan broken symmetry in discussin lective modes in the excitation s of solids involving electrons, ph and magnons.

Neville Francis Mott is S Research Fellow at London's Im College since 1971. Earlier, he the Director of the H. H. Laboratory at Bristol and Cave Professor of Experimental Physi Cambridge University.

Along with many scientific pa Mott has published several b which have a profound influenc scientific workers. His work *Theory of Atomic Collisions* written H. S. W. Massey (1933) was standard reference on the quar mechanical scattering theory for n years. In 1936, with H. Jones, published a classic work, *The T of the Properties of Metals and A* which immediately became the so book of metal physics. In 1971, E. A. Davis, he published *Elect Processes in Non-crystalline Mate* summarising his fundamental co





Far left: Van V
left: Anderson

butions in the study of amorph materials, a field he has domina from 1960. Another widely re publication is *Metal Insulator Tra tion* (1974).

The conventional distinction metal, semiconductor and insula is based on A. H. Wilson's ba theory. The electronic energy sta in a solid are grouped into bands allowed levels separated by disallow or forbidden gaps. If some bands a partially filled by electrons, the so is a metal. The electrons can mo easily under the influence of external electric field, because the are levels accessible without a appreciable cost of energy. If sor bands are full and separated from t lowest unfilled band by a large fo bidden gap, the electrons cannot

ıced to carry electric current
y and the solid is an insulator. If
gap is small, however, thermal
tations may take a few electrons
unfilled bands, and the current
flow. The material is then a
iconductor with conductivity
ngly dependent on temperature.

ı 1949, Mott discussed the limita-
s of this naive picture (*Proceed-
of the Physical Society* (London),
1949, pp. 416–422). He noticed
several oxides, like NiO and
), should have unfilled bands
nergy levels and be metallic, but
e in fact insulators. At least for
ı materials, Mott felt that the
elated motion of all the electrons
ıld cause the localisation of elec-
ıs and render these materials
ılators. An analysis of the physics
his problem led Mott to expect
t these correlated motions would
nge character all of a sudden and
l to a sharp insulator-to-metal
ısition.

n 1958, Anderson studied a local-
ion problem in a paper called
bsence of Diffusion in Certain
ıdom Lattices" (*Physical Review*,
, 1958, pp. 1492–1505). The
blem studied and the theorem
blished can be best described in
own words: "A number of
sical phenomena seem to involve
ntum-mechanical motion, without
particular thermal activation,
ong sites at which the mobile
ties (spin or electrons, for example)
y be localised. The clearest case is
t of spin diffusion; another might
the so-called impurity band con-
tion at low concentration of im-
ities. In such situations we suspect
t transport occurs not by motion
ree carriers (or spin waves), scat-
d as they move through a medium,
in some sense by quantum
chanical jumps of the mobile
ities from site to site. A second
ımon feature of these phenomena
randomness: random spacing of
ourities, random interactions with
'atmosphere' of other impurities,
dom arrangements of electronic or
clear spins. . . . The theorem is
t at sufficient low densities, trans-
t does not take place; the exact
ve functions are localised in a small
ion of space".

The formal mathematical machi-
y was formidable: perturbation
es, random distribution of elec-
nic energy levels, stochastic averag-
of the perturbation series, percola-
ı theory, and convergence question
such stochastically averaged series.
cause of the great mathematical
ficulties, the paper drew little
ice, until Mott realised its import-
ce in the localisation problem.
Inspired by Mott and Anderson, the entire basis of conventional solid state physics has been re-examined. New theories of the insulating state have been proposed; exotic phenomena like excitonic insulators and many metal-to-non-metal transitions have been studied. The phenomenon of conduction in amorphous materials is now the subject of intense experimental and theoretical investigation. There are hopes that these materials when understood further may cause a new technological revolution.

Far left: Mott, left: Prigogine

Finally, a few personal traits of these scientists. W. Kohn and P. W. Anderson, both students of Van Vleck at Harvard, say that Van Vleck likes to read the railway time-tables very thoroughly and can off-hand describe how and where to change trains in any train journey in the US.

Mott once agreed to discuss physics with a student with a surname Taylor. At the appointed hour, he went away to talk to the famous physicist G. I. Taylor. On another occasion, Mott was visiting Oxford. His wife and daughter left the car with him at the University and went for shopping. When Mott finished his work at the University, he simply drove away to Cambridge, more than 150 km away, leaving his wife and daughter at Oxford. Such was Mott's absent-mindedness, according to T. M. Rice who has described several such incidents.

C. K. MAJUMDAR

[Prof. Majumdar is Palit Professor of Physics at Calcutta University.]

CHEMISTRY

The prize in Chemistry has been awarded to Professor Ilya Prigogine of the Universite Libre de Bruxelles, Belgium. Prigogine has brought a revolution in the field of thermodynamics by extending the subject to non-equilibrium open systems.

To understand his basic contribution, recall the standard Second Law of Thermodynamics. This states that the evolution of an isolated physico-chemical system, which cannot exchange energy and matter with the surroundings, leads to an equilibrium state of maximum disorder. In other words, entropy S increases monotonically until it becomes a maximum. This law, which is one of the most fundamental in thermodynamics, implies that in an isolated system an increase in overall ordered structure is impossible. How then can there exist such highly ordered structures in nature such as man himself?

Prigogine felt, therefore, the necessity of generalising thermodynamics (which deals with isolated equilibrium systems) to non-equilibrium open systems to solve this problem. And as early as in 1947, he gave a generalised formulation of the Second Law of Thermodynamics applicable to non-equilibrium open systems.

Take, for example, an open system which can exchange matter and energy with the surroundings. Then the variation dS of the total entropy of the system in time can be written in the form $dS = d_eS + d_iS$, where d_iS is the entropy production due to irreversible processes *inside* the system and which is always positive according to the Second Law of Thermodynamics, and d_eS is the flow of entropy due to exchanges with the surroundings which may be either positive or negative. The system can then reach a *steady state* for which $dS = 0$ or $d_eS = -d_iS \leqslant 0$. Thus a system can be maintained in a non-equilibrium ordered state by supplying negative entropy to it.

Prigogine and his collaborators have extensively developed this concept and investigated the problem of creation and stability of such ordered states. Most of the systems studied by science, be it the nucleic acids in the biological cell, the terrestrial atmosphere, or the matter in the Sun are precisely such non-equilibrium, open, ordered systems. How do their specific

structures arise in such cases? Are there any general rules of formation and transformation of such structures? Prigogine's contribution to this problem concerns a class of systems in which the irreversible (entropy producing) processes exceed a certain threshold and give rise to ordered structures which are, therefore, known as "dissipative structures". Such systems can be maintained in various distinct structural states which are separated from each other by points of instability. The transformation of structure across such instability thresholds is effected by *fluctuations* which are always present in every system and are usually negligible — except at the instabilities where they tend to grow. These developments have opened up new areas of scientific research due to the applicability of the Generalised Thermodynamics to numerous non-equilibrium, non-linear processes that characterise most systems around us.

Generalised Thermodynamics, like the thermodynamics that preceded it, is a macroscopic, phenomenological theory. Prigogine appreciated the need for any phenomenological theory to be supported by a corresponding microscopic theory. Equilibrium thermodynamics can be said to be reasonably well-understood (apart from the problem of phase transition) by equilibrium statistical mechanics. Prigogine and his school at Brussels extensively developed non-equilibrium statistical mechanics and, from there, tried to derive the generalised thermodynamics. Though it cannot be said that this has been fully achieved, one must admit that much progress has been made in that direction.

Besides being one of the most profound scientific thinkers of modern times, Prof. Prigogine is an extremely dedicated teacher. He has formed a school of statistical mechanics at the University of Brussels which has been recognised as one of the best centres in the subject. The academic atmosphere that he has created at Brussels University is a source of inspiration for all who visit it.

Prof. Prigogine is very fond of music and painting. He has a great fascination for Indian philosophy. He visited India in 1968 and gave talks at Matscience in Madras and the Tata Institute of Fundamental Research in Bombay.

A. C. BISWAS

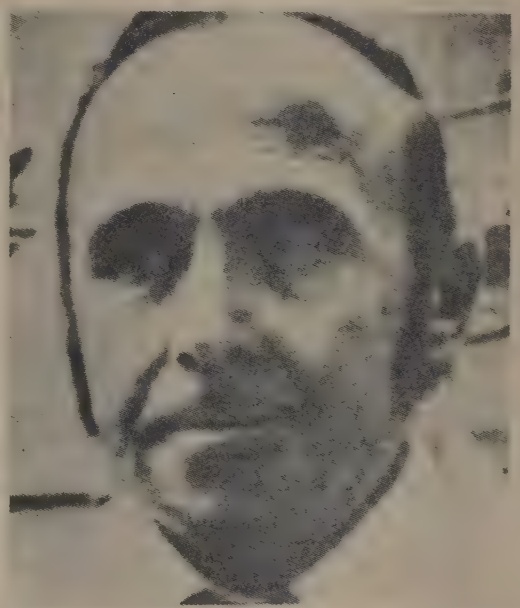
[Dr. Biswas is with the Theoretical Physics Group at the Tata Institute of Fundamental Research, Bombay. He worked with Prof. Ilya Prigogine during 1965–1969 to receive his PhD in Statistical Mechanics from the Universite Libre de Bruxelles.]

MEDICINE

The Nobel Prize in Physiology or Medicine has been awarded to three scientists — one-half to Rosalyn S. Yalow of the Veterans Administration Hospital in Bronx, USA, and the other half to Andrew V. Schally of the Veterans Administration Hospital in New Orleans, USA, and Roger C. L. Guillemin of the Salk Institute in La Jolla, California, USA. Yalow receives the prize for her work in the development of the radioimmunoassay (RIA) technique, and Schally and Guillemin for isolating, characterising and synthesising polypeptides which control the anterior pituitary function.

For a long time, it was believed that the pituitary was the master gland (conductor of an orchestra) which controlled the functions of all the vital organs in the body. Schally and Guillemin's work established that it is the higher brain centres such as the hypothalamus which regulate the pituitary, thereby affecting all the organs.

The need for assay methods sensitive enough to detect minute concentrations of hormones, drugs, etc in blood and other body fluids has resulted in the development of extremely versatile and sensitive analytical techniques such as radio-



Far left: Ya
left: Schall

immunoassays, which have revolutionised clinical endocrinology. These methods have provided tools that have enabled investigators to clarify the pathophysiology of diverse endocrine diseases, for example, infertility, diagnosis of tumours, disorders of growth, diabetes, etc. They have also allowed them to pose basic questions in the biochemical mechanisms of hormone synthesis, secretion, transport action and degradation. And, at the same time, they have made sophisticated diagnostic tests readily available to physicians.

Competition between labelled and unlabelled hormone for specific bind-

ing sites on the antibodies hormone is the basic princi radioimmunoassay. If the qua of the labelled hormone and body are constant, the num molecules of labelled hormon bind to antibody is an inverse tion of the number of unla hormone molecules added t system. Thus, the higher the co tration of unlabelled hormone, the degree of binding of la hormone and the lower the co tration of unlabelled hormone greater the degree of bindi labelled hormone. For instance mixture of anti-insulin antibody labelled insulin is incubated, pa the labelled hormone will be bou the antibody and part will re free in the solution. If the amou labelled hormone and antibody kept constant, and the unlab hormone is added, the amour labelled hormone bound to anti will be decreased. This can be sured by determining the rati bound to free radioactivity.

It would seem rather strange, RIA owes its birth to diab Way back in the early fifties, w Soloman Berson and Yalow studying the in vivo behaviou radio-labelled proteins, Arthur M hypothesised that diabetes did always seem to be due to a defici of insulin, but might rather be consequence of an abnormally a

degradation of insulin by hep insulinase. This kindled the inte of Berson and Yalow who exten their investigation to the metabol of labelled insulin, and made the rat astounding discovery that virtually insulin treated diabetics had insu binding antibodies.

Their initial attempts to publ this information, however, were very successful, for the first jour to which they submitted the pa rejected it after several months wit comment that "everyone knows t insulin does not make antibodies The next journal, however, accep it, though with similar reservations

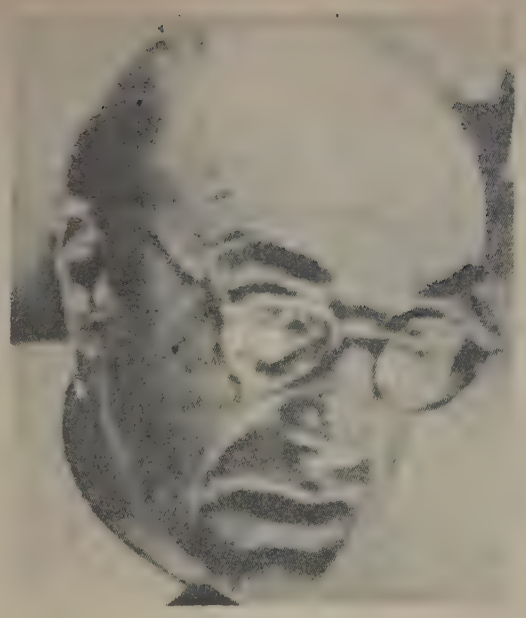
y were not permitted to use the
m " insulin antibody " in the title
he paper.

n this early work, they established
t the binding of labelled insulin is
uantitative function of the amount
insulin present when the antibody
ncentration is kept fixed and that
elled insulin can be displaced by
abelled insulin. This formed the
is of the RIA of plasma insulin,
ich was first presented in 1957.
The developments in the field are
w so rapid that a complete sum-
ry of RIAs cannot be kept up to
e easily. In later years, the princi-
of RIA was extended to non-
mune and non-hormonal systems.
e first application of competitive
As to substances other than peptide
rmones was in the measurement
vitamin B_{12} and thyroxine by
Rothenbey and Dr. R. Ekins
rtly after the development of the
ulin RIA.

The recent use of cell-receptor sites
the adrenal gland for ACTH repre-
ts an ingenious new application of
same principle. The first vital
rticle to be assayed by this method
s the Australia antigen by Walsh,
low and Berson.

At a time when direct evidence for
existence of any hypothalamic
ulatory hormone was lacking,
nally got involved in this problem
an undergraduate, working with
. Murry Salfram at the Department
Psychiatry at McGill University,
ntreal. They were able to demon-
ate that hypothalamic tissue con-
ned a substance which stimulated
release of ACTH. They named
substance corticotropin-releasing
tor (CRF). This was the first direct
of of the existence of hypothalamic
rmones. CRF activity proved to be
y difficult to purify because of its
tability and despite agonising
orts, they were unable to isolate
ough material in pure state for the
termination of its structure.

Schally continued these efforts with
illemin in Houston, Texas. They
ed several frustrating years as their
lure to identify CRF, owing to the
hnological problem involved in the
ort, cast doubts on the initial
dings. Nevertheless, while many
entists and physicians in the
docrine field treated their work with
rcasm, skepticism and ridicule, they
ntinued their work, confident of the
istence of hypothalamic hormones
gulating anterior pituitary function.
d when he was offered the post of
ad of a Veterans Administration
boratory devoted to research on
hypothalamus, Schally quickly
k it up. There he worked on all the



Guillemin

hypothalamic hormones controlling anterior pituitary functions and was able to demonstrate for the first time that hypothalamic materials release LH by direct action on the anterior pituitary.

At this stage, while he was hard at work on thyroid releasing hormone (TRH), GH-RH and prolactin release-inhibitory hormone were added to the list of research projects. In 1966, they established that TRH was a polypeptide and thus helped to solve the confusion that TRH and LH-RH might not be polypeptides.

In 1969, when Guillemin's group announced the three amino acids in ovine TRH, Schally, who had been deeply involved in GH-RH at the time, realised that he had been on the right track with TRH too. He teamed up with Karl Folkus, who had several structural chemists in his laboratory, and restarted working on TRH. The credit for completing the TRH project, however, had to be shared with Burgus and Guillemin who also solved the structure of ovine TRH at about the same time in 1969.

Solving the structure of TRH removed much of the skepticism surrounding the work on the hypothalamic hormones and Schally and his group were able to devote more time to LH-RH and the release of LH. The rigorous and agonising efforts finally met with success in the subsequent year in the form of 800 μg of LH-RH from 160,000 hypothalami, along with proof from proteolytic enzymes and amino acid analyses that it is a polypeptide. By 1976, they were able to draw unambiguous conclusions about the amino acid sequence.

ANIL R. SHETH
S. B. MOODBIDRI

[Dr. Sheth is Assistant Director, Institute for Research in Reproduction, Bombay, and heads its Biochemistry Division. Dr. Moodbidri is a research officer at the Institute.]

ECONOMICS

The Economics prize is shared by Prof. Bertil Ohlin of Sweden and Prof. James Meade of Britain for their contribution to International Trade Theory. The winners must have figured fairly low down in almost everyone's list of likely candidates. For, the work for which they have been honoured was done many years ago, and is relatively obscure. However, unlike last year, this year's awards will not raise any political storm. The award of the prize to Milton Friedman of the USA last year created a controversy in view of his role as an Economic Adviser to the right-wing Chilean military junta.

The theory of international trade deals primarily with trade between nations. To classical economists, the distinguishing characteristic of a nation was the combination of internal mobility and the international immobility of factors of production. They contributed the theory of comparative costs which explained both the cause and mutual beneficiality of international trade in terms of differences in the relative costs of production. Contemporary trade theory attempts the more fundamental task of explaining these differences by the differences in the ratios in which countries are endowed with factors of production. Professor Ohlin's *Interregional and International Trade* (1933) was a significant and fundamental contribution in this area.

The Heckscher-Ohlin model, so named because it was also independently formulated by Heckscher, is a simple, stylised version of the world economy, postulating two countries each producing two commodities with two factors. The demand and production conditions are identical to both, but the ratio of factor endowments differs. This results in the proposition that a country exports the commodity which uses more intensively the factor of production which is relatively abundant in supply, and correspondingly, imports the commodity which uses more intensively the factor which is relatively scarce. This theory was challenged by W. Leontief's (1973 Nobel-prize winner) empirical findings that US exports were more labour-intensive than US imports. Supporters of Ohlin's hypothesis, however, point out that this may not be a fair test since Leontief ignored the possible influence of other factors such as natural resources.

The Heckscher-Ohlin theory may be a plausible approach to the explanation of trade in those products

(Contd. on p. 51)

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f strokes and hypertensions

PERTENSION AND STROKE NTROL IN THE COMMUNITY
oceedings of a WHO meeting held Tokyo, March 1974, World Health ganisation, Geneva, 1976, pp. 362, .fr. 30.

Though several books have been written on hypertension, there are only a few on epidemiical studies on stroke and hypersion in a defined population. This k contains very valuable informan based on the proceedings of a HO meeting in 1974. The editors e well brought together important tributions of nearly 30 experts n all over the world.

The first part of the book lays phasis on "Hypertension and ke as worldwide problems". Hatano has pointed out graphic- that the mortality rate from ertensive disease has fallen in ous countries over the preceding rs and this, in turn, is likely to ease the morbidity rate in the ivors. He has also brought out an ortant observation that *the falling l in the mortality started long before introduction of new anti-hypertension s.* His recommendation that community surveys for early detection of hypertensive subjects, with a view to preventing morbidity (for instance, stroke) should, therefore, form a part of a comprehensive well co-ordinated cardiovascular disease control programme integrated into the national health plan, is meaningful.

In "The control of hypertension and stroke in populations", Dr. Strasser has stressed that any public health programme in a community for disease control should be cautiously planned only after gathering relevant information. Dr. Y. Fukuda's contribution on daily fluctuations of blood pressure in any given case is worth reading; thus, repeated measurement of blood pressure at different time intervals, would be far more helpful in arriving at a mean figure before classifying anyone as having mild, moderate or severe hypertension. Prof. Omae asks the basic question: "What does diagnosis of hypertension mean?", and today we still do not know at what level of blood pressure should we label someone as "hypertensive".

In "Borderline pathology", Dr. Doyle discusses the crucial issue on "The dilemma of mild hypertension" and Masao Ikeda brings out useful information on the "Prognosis and pathology of mild hypertension and systolic hypertension in the aged". J. Marquardsen raises a very important point about treatment of "Transient cerebral ischaemia" (TIA) as a "medical emergency" to prevent a major stroke. This is still a controversial subject because only 15 to 30 per cent of such patients develop a stroke; unfortunately, there are no reliable guidelines or criteria to decide who will develop it.

Dr. Freis has advocated effective control of high blood pressure (diastolic level of over 105 mm Hg) to prevent stroke and particularly in those who are under the age of 60 ("Guidelines for action"). On the other hand, Dr. Hoobler raises serious doubts about control of "mild" hypertension even in patients who had transient ischaemic attacks before developing a major stroke. Dr. Shmidt proposes establishment of "emergency service" and a "mobile team" of stroke specialists, but the cost-benefit ratio for such a venture in any community needs to be carefully worked out. Dr. Weiss has rightly emphasised

(*Contd. on p. 65*)

BEL PRIZES (*Contd. from p. 49*)

ch are highly intensive in localised ural resources but not very helpful xplaining the composition of trade industrial products between adced industrial countries, which ounts for a major share of world e. Various alternative theories e been advanced to get over these tcomings, but none of them quite ch the analytical rigour of Prof. in's work.

hlin managed to combine his acaic career with political activity at highest level, and apart from being Minister of Trade in Sweden's –45 coalition government, he also the leader of the Swedish ral Party from 1944 to 1967.

mes Meade, formerly Professor of ical economy at Christ's Church ege, Cambridge University, is now Honorary Fellow of the same ge. He has been awarded the primarily for his *The Theory of national Economic Policy* (1955) in volumes. Meade's work is of t topical interest. In view of the easing tendency towards economic gration amongst different countas evidenced by the growing popularity of the European Common Market and suggestions for an Asian Common Market, arrangements like "customs unions" are gaining new importance. A customs union, while eliminating tariff barriers amongst member countries, aims for a unification of national tariffs in a common schedule. Meade developed an elaborate analytical apparatus for analysing the effects of tariffs and other policy changes on the welfare of a nation when introduced in an economy whose equilibrium is distorted by tariffs, taxes, etc which prevent prices from corresponding to the social costs or value of goods. He formulated a number of propositions about the circumstances in which a customs union is likely or unlikely to increase welfare, and also demonstrated that a preferential tariff reduction is more likely to be beneficial than free trade in such a union. Meade's major contribution in this area is in providing a theory that is capable of quantitative application to practical policy problems.

Today, the theory of international trade is mainly an application of general and monetary theory to a special case in which decision-making units are not individual households or firms, but are grouped into countries (or regions). There has been very little feedback from trade theory to general economic theory. Meade's work, which is an exception to this general phenomenon, deals with a choice among alternatives when a welfare-maximising solution cannot be achieved due to circumstances beyond the planner's control. This being the nature of most policy problems in economics, Meade's theoretical construction is of great general applicability and has inspired a lot of work in an important area known as the theory of second best economics.

Besides his contributions to international trade theory, Prof. Meade is the author of the 4-volume, *Principles of Political Economy*. He has increasingly advocated State intervention to correct inequalities in income and wealth and is currently the chairman of a committee set up by the Institute for Fiscal Studies to review the structure of British taxation.

BHASKAR DUTTA

[Dr. Dutta is with the Centre for Advanced Studies in Economic History and Economic Development, Delhi School of Economics, University of Delhi.]

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MIXED AND EVERGREEN FORESTS

TREWIA. THE CLOSE-UP SHOWS PINDARA FRUITS

It would be hard to find an individual who is so insensitive as to be unmoved by the sight an exuberant growth of many kinds trees growing together. This xuberance finds its richest expression the dense tropical rain forests hich harbour many species of ever-een trees. In many forests, mixed mmunities of both deciduous and ergreen trees grow side by side.

A common tree found throughout dia in many diverse types of forests, pecially in moist and swampy gions, is the 'false white teak' *rewia nudiflora*) or **pindara** (in indi). This tree is deciduous and ses all its leaves during the late onths of the year till summer, but th the onset of the monsoon, it puts t its leaves in abundance. It's a edium-sized tree with a greyish-own bark which flakes off, from ne to time, to be replaced by a w layer. In some forests, fairly large ecimens are found, about 20 metres gh and buttressed at the base of the unk. The leaves of the pindara tree e heart-shaped, about the size of e's hand, and have a slightly wavy argin. One notices that the leaf lour is a dull green washed with ht brown. Like many members of same family (Euphorbiaceae), its wers are small, unisexual and lack tinct petals. An interesting feature the species is that male and female wers are borne on separate indivi-als. During the early months of the year, the trees flower and after fruiting occurs one finds only some trees, the female trees actually, bearing bunches of fruits.

Pindara fruits are borne on a short stalk each in the axils of the leaves. Each fruit, a dull dirty green in colour, is hoary, roundish and appears to be slightly compressed with a shallow groove going right around. Inside, one or two black seeds are surrounded by a thin white pulp which is edible and has a sweet but flavourless taste. Village folk of western India, who call the fruit *petari*, occasionally eat the pulp of ripe fruits. (To reach the pulp, one has only to separate the stiff external skin into two parts at the groove.)

The finest burst of growth of the pindara is seen during the monsoon, when small coppice shoots are thrown up by cut stumps jutting out of the soil. Regeneration from seeds also occurs during the rains. During this time the young saplings sport very large leaves and shoots whose surfaces are covered with a light brown and flocculent woolly down. In the western Indian forests, flowering, followed by fruiting, occurs from June to September, and at this time aggregations of colourful sap-sucking bugs and spotted ladybird beetles find a haven among its leaves and bunches of fruits.

Pindara wood is soft and white, and is sometimes used for making toys, cheap planking, matches and the like. In native medicine its roots, ground and made into a poultice, are used as an application for rheumatism; a decoction of the shoots is used to treat flatulence. Though the leaves contain an alkaloid, called nudiflorine, cattle sometimes eat them, apparently without any harmful effects.

Many kinds of trees do not shed all their leaves together but retain them throughout the year, the old ones being gradually replaced by fresh leaves in a continuous fashion. Such evergreen trees offer the only shady spots during the summer in mixed forests. The best specimens are found in the heavy rainfall areas where the soil is rich and fertile.

A common and important evergreen tree found throughout the greater part of India up to 1,500 metres altitude is the **kamala** tree, called *kapila* or *kampillaka* in Sanskrit (*Mallotus philippinensis*). The kamala is a small-to-medium-sized tree with a short trunk and a rather profusely branching crown. It has a rough and

(LEFT) THE *ALSTONIA* OR SAPTAPARNA TREE. (ABOVE) *ALSTONIA* LEAVES

greyish brown bark and in older trees the base of the trunk may be buttressed. The alternately-arranged leaves range from 8 to 20 cm in length and though variable in shape, are generally broad and pointed. The dark green upper surface contrasts markedly with the paler colour of the underside. The lower leaf surface is worth a closer look with a powerful magnifying lens which reveals a large number of minute red glands dotting the entire blade from end to end.

The flowers are unisexual, male and female flowers being borne on separate trees. As in the case of the pindara, the kamala flowers lack distinct petals and are small; male flowers are the more conspicuous, in pale yellow clusters of long spikes, while the female flowers grow from shorter spikes. The flowering season varies from place to place but is generally from July to October, followed by fruiting from about November to April.

The kamala fruits — clusters of one centimetre diameter, round three-lobed red capsules — make a pretty sight against the dark green foliage. The red colour is due to a dense covering of minute hairs and grains of a red resinous substance. This red secretion from the glands is the source of the dye commercially known as 'kamala'. The capsules split open on ripening and discharge the small, dark brown seeds. The forest floor in the summer is often sprinkled with the red colouring matter and dried skins of the capsules — usually the first indicator of the tree's presence.

In the economy of a forest system, the kamala tree plays an important part. It is the first to grow in worked areas from the numerous root suckers produced by the plant and also by coppicing; this serves to crowd out grasses, thus allowing economically valuable trees to grow. In this manner it acts as a nurse, as it were, to other trees, especially the *sal* (*Shorea robusta*) which is a source of excellent timber and seed oil. It is also frost-hardy and drought-resistant.

Since ages, kamala dye has been collected and employed for imparting a flaming orange-red colour to silks and woollens. The resinous grains of the dye can be removed from the dry capsules by the simple expedient of shaking them loose in a bag. The dye has also been used as a colouring agent and as an antoxidant preservative for fats and oils. Kamala powder was used in native medicine as an anthelminthic to remove tapeworms infesting the intestinal tracts of human beings and livestock. Its use, however, causes purging and nausea, and it has been replaced by safer modern drugs. The active principle is a chemical, rottlerin, and its isomer isorottlerin. Another indigenous medicinal use of kamala is its external application in skin diseases. Experimentally it has been reported to reduce the fertility of rats and guinea pigs. The seed oil, which is quick-drying and viscous, has been used in paints and varnishes.

Kamala leaves serve as cattle fodder sometimes, though R. S. Troup, who is well-known for his work on the silviculture of Indian trees, states that the plant is not readily browsed by cattle. Kamala wood is light red-grey in colour, fairly hard and strong and used for construction work. Kamala powder was also formerly used by Hindu women as a vermilion forehead mark (*tilak* or *kumkum*).

The dense evergreen forests of the Deccan peninsula and the heavy rainfall belts of eastern and western India, and the Andamans, are the home of an exquisitely be ful small tree — the local folk c **anjani** or **karpa.** Known also a 'iron wood tree', it bears a cha ingly aesthetic Sanskrit name, *n shok*, and it is by this name Valmiki has referred to the tre the Ramayana. (The botanical n is *Memecylon umbellatum.*)

The neelashok grows gregario and one may encounter almost stands of these trees over exten areas. (Visitors to the hill station Matheran and Mahableshwar Maharashtra would notice this.) tree has a relatively thin trunk w grey bark vertically furrowed. Th furrows, filled with decaying orga matter especially during the ra give a foothold to mosses, ferns a orchids with which the trees are of festooned. The low canopies of th trees usually form a confluent sha roof preventing the harsh sunlig from penetrating the underlying s As a result, many shade-loving shru and herbs find shelter under them, also the small forms of life that burr into the rich humus and find a refu — like the harmless and docile roug tailed and blind snakes, earthworn and the like.

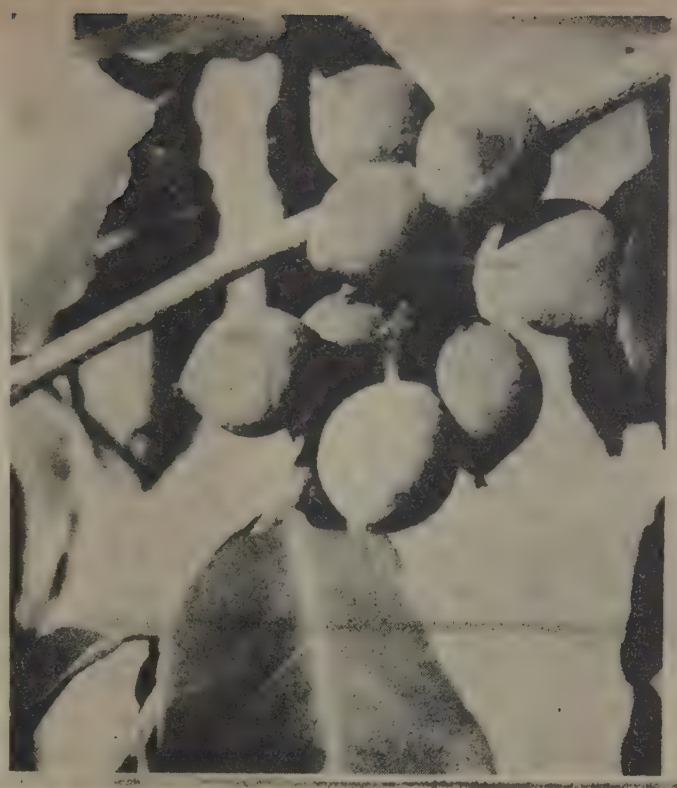
The oval leaves of the neelash are about 5 cm long, smooth to t touch and dark green in colour wi a bright sheen. Small tube-like flowe varying in colour from a bright blu to a delicate purple, appear in cluste just before the rains (March–Apri on the woody portions of the lea branches. The Sanskrit name refers t the colour of the inflorescence. Durin the monsoon the fruits develop; thes are pea-like berries which turn dee purplish-black. The berries are edibl and have a slightly astringent an acid-sweet taste.

The neelashok, being a handsom tree, has been even introduced int some gardens since it can be propa gated by seed. In the wilderness, cu stumps also grow by developing cop pice shoots. Its leaves are known t yield a small amount of a yellow dy used for dyeing mats and cloth. I indigenous medicine the leaves ar described as being cooling and astring ent, its lotions used in eye diseases and applied to bruises. The leaves form a excellent mulch for enriching the soi — the luxuriant humus formed under the trees in the natural habitat bears testimony to this. The dark brown heartwood of neelashok is extremely hard and durable. I have known villagers in the Western Ghats to cut down V-shaped or Y-shaped trunks and side branches to fashion ploughs out of them. House posts, rafters, etc, are also made from the wood. The toughness and durability certainly

tify the choice of the English mmon name.

In the Indian lages, strange beliefs persist about magical properties of parts of ants. While the origin of such beliefs often lost in the mists of time, actices associated with them may ger on. One such popular notion is at hanging a necklace, made by inging together the stones obtained m the fruits of the **putranjiva** tree, ound a child's neck protects the ung one from the "evil eye". The tranjiva tree is of interest, too, cause this evergreen tree, generally nd in many forests in India, is also rather popular roadside tree in many wns and cities. An evergreen spread- g tree would be an obvious pave- ent tree for the cool shade it provides roughout the year, quite unlike many ciduous ones. The botanical name *tranjiva roxburghi* is adapted from Sanskrit name (*putranjiva*) meaning life of the child", and also honours r. Roxburgh, physician with the stwhile East India Company, who as famous for his excellent illustra- ons of Indian plants.

The putranjiva has a grey bark, ghtly mottled with white on closer spection, and grows to a height of bout 20 metres on good soil. In old ees, especially those bent by wind d weather, the 2 to 3 cm thick bark nds to develop vertical cracks expos- g the underlying wood. The 5 to cm long thick and elliptical, dark een leaves arise alternately from nder branches which tend to droop, ving the tree an aspect which is miniscent of the mast tree for which is sometimes mistaken. The small, eenish white flowers are unisexual d, as in the case of trees mentioned rlier, are borne on separate trees clusters in the axils of the leaves. When unisexual flowers are borne on parate trees, that is, there are male d female trees, they are said to be *ecious*). These appear from March May, and the fruits appear later on d persist very long on the tree. Each



(RIGHT) A PUTRANJIVA TREE IN BOMBAY. (ABOVE) CLOSE-UP VIEW OF PUTRANJIVA FRUITS

fruit is ellipsoid with an outer green and slightly furry covering, enclosing a single seed in the hard, corrugated stone inside.

Besides serving as a shade tree on roads, the putranjiva is sometimes grown as a hedge in which one may sometimes see stunted plants looking like shrubs. In its natural habitat, the tree prefers good alluvial soil which is found near river banks and marshy land. Putranjiva fruits are eaten by herbivorous animals and bats which are responsible for their dissemination; subsequently, the seeds germinate during the rains.

Putranjiva timber is whitish-grey and suitable for general purposes like tool handles, agricultural implements, etc. The seeds yield a fatty oil used as an illuminant; it also contains some glycosides, which are also found in the shoots and roots. A decoction of the leaves is a native medicine for cold and fever and the leaves themselves are used as fodder.

When a patch of evergreen forest is cleared for any reason it leaves a lacuna which is sometimes invaded by grasses. Many seedlings of the larger trees are then unable to withstand the competition and may die out without being able to colonise the patch. A rapidly regenerating tree whose seeds take over such patches and "crowds out savannah grasses", as Troup says, is the rather unusual-looking tree *Macaranga peltata* (**chanda** in Hindi). This serves to reconvert the cleared land into a suitable place for valuable tree species to gain a foothold.

The rather unusual feature of the chanda tree is the shape and attachment of its leaves. Each leaf is rounded at the base and pointed at the apex — but its petiole (leaf stalk) is attached, not at the base as in other plants but on the flat undersurface at the leaf mid-rib a little off-centre. The leaves, therefore, look like so many shields each held by an outstretched arm! Hence, of course, the descriptive specific name *peltata*, from *peltum* — meaning a shield in Latin.

The chanda tree is found abundantly in the mixed and evergreen forests of the Western Ghats, the Deccan Peninsula, West Bengal, Bihar and Orissa. It has a grey-black bark and a moderately thick trunk and is rather

GHT) CHANDA AVES WITH THE EE CANOPY OWN IN THE OTOGRAPH FAR GHT

medium-sized. It has a fine branching crown of dark green foliage, each shield-like leaf being on an average the size of one's hand. In young plants, the leaf is of immense proportions, for example, as long as the forearm and almost as broad; saplings also have a green stem filled with white pith and are mucilaginous if bruised. The trunks of old trees, on the other hand, bear many irregular corky mosses. The base of each leaf-stalk has a pair of leaf-like stipules joined together.

Both male and female flower bearing trees occur. Male flowers, more numerous as usual, are small, greenish and clustered, whereas the female flowers are few (sometimes even single) in the angle of the leaf-stalk. Flowering occurs usually about the time of the rains, and the small capsular fruits are globose and green when ripe, turning dark as they ripen. Though not usually eaten, chanda fruits are used as a famine food.

The leaves of the chanda are not eaten by cattle, but can be used as manure. The tree is favoured as a shade tree for coffee. From the cut parts of the tree a red gum, resembling *kino* gum, exudes; this has been employed for sizing paper and for making impressions of coins, medallions, seals, etc. The bark and leaves contain large amounts of tannins, and a decoction made from these parts is used as a folk-remedy to wash ulcers. Chanda wood — soft, smooth, light and greyish in colour — is used for making paper and matches.

An interesting tree often planted on pavements and gardens is the **saptaparna** (Sanskrit), also called *datyuni* (Hindi) or the 'Devil tree'. (*Alstonia scholaris*). This native of the evergreen tracts of Western India grows straight with a clean grey bole (which in older trees may be buttressed) to a height of 10 to 12 metres. A tree which has been allowed to grow straight and true looks very much like a Christmas tree in profile because of the whorled arrangement of its branches, gradually getting shorter towards the top.

The leaves of the saptaparna, as the name suggests, between 5 to 7 in number, are arranged in a whorled manner at a single point of attachment on a stalk, looking deceptively like a digitate leaf. Each leaf is in fact an entire, single leaf, 8 to 20 cm long and 2·5 cm broad, dark green and shining. The tree has been called *saptachhada* in the Valmiki Ramayan. The bisexual flowers which bloom in clusters are small and greenish-white with a tubular, cylindrical corolla. The fruits are a pair of follicles resembling those of the *kurchi* tree and of about the same size. Each follicle contains thin, very small linear seeds, each with a tuft of hair at one end to aid dispersal by wind. Flowering occurs during September–November.

The tree exudes a milky juice if injured, and this exudate has b used in native medicine as an appli tion for ulcers, as embrocation rheumatism and, mixed with oil, topical drops for ear-ache; a tinct of the bark is reputed to increase flow of milk (galactagogue actio Fresh bark extracts are used as anth minthic. It has been shown by che ists to contain the alkaloids ditam and echitamine. The bark, sold *dita* bark, is a native remedy diarrhoea and dysentery.

Saptaparna timber is white to p brown, light and soft, and is used making packing-cases, chests, pen and matches.

A brief sample survey of our tr sury of forest trees does scant just to our rich heritage which is alrea showing signs of deterioration. Hist records the conversion of lush gre lands into arid deserts in many pa of the world by the hand of ma Isn't it time (or is it well past t time?) we saw the writing on the w and acted to save what's left of o flora?

S. R. AMLA

(LEFT) CLOSE-UP VIEW KAMALA FLOWERS

KARPA

"If I were you, I would enter his name for the Science Talent Search exams."

earn while you play—13

. D. KELKAR
. V. DESHINGKAR

Have you ever been frightened by magic shows where human heads or st the limbs floated across a rkened stage? How did the agician perform the trick? It's ite simple really: the magician's des had only their heads or the nds and legs visible, the rest of eir body covered with black nics, masks and gloves. Since e stage had a black backcloth, e audience could see nothing t the apparently dismembered ads, legs or hands dancing out! This explanation is found- on a fundamental concept out colour: *black reflects no light all and cannot be seen except as a ntrast against a lighter background.*

It must be a thousand times at you have asked why the sky blue, the grass is green, the rth is brown! Would you be rprised if we said, the blue sky, e green grass, the brown earth *ve no colours of their own?* Their lours are the result of the way which they reflect parts of the ht that shines on them. Take, example, this very page you e reading now. The paper pears white because it reflects st of the light shining on it. ie print appears black because does not reflect any light. In a y the printed letters are ' holes ' the light reflected back by the ge. If you take this page in to dark room, the print wouldn't appear, only it won't be seen cause there will be no contrast- g whiteness of the paper.

Now, the white light that lights the page is actually composed seven colours. Way back in 88, Isaac Newton passed white ht through a prism and de- onstrated the dispersion of white ht into its spectrum. The rea- n behind this dispersion is that fferent colours of the spectrum ve different wavelengths. The our of a substance comes from wavelength of the light that reflected by it, and the colours absorbs. A black substance sorbs all the light (irrespective the wavelength) that falls on it; white substance reflects every- ng back. The chemical structure of a substance also has something to do with it. For example, in the case of grass, the wavelengths of light that represent the red, yellow and violet parts of the spectrum are absorbed. We see the remaining *reflected* part — the green light.

To learn something more about colour, let's try a simple experiment.

Let's prepare a disc of 6 cm diameter from white drawing paper and colour it black as shown in Fig. 1. Fix the disc on a spinning top and rotate it at relatively low speeds (4 to 15 revolutions per second) and observe it in daylight. You will find faint shades of violet, blue, green, yellow and pink colours appearing on the disc. (You can also support the disc on a needle and rotate it by driving the disc with your finger.)

The reason for the colour illusion is that the retina of the eye responds more quickly to some colours than to others. Since the white image of the disc moves around on the retina and since white light contains all colours of the spectrum, some colours are perceived at each given spot on the retina sooner than others and produce the colour effect.

When the disc revolves at a synchronous speed, a steady pattern of the designs appears on the disc, and the black spots will be seen as brown and the white as faint blue. Because the design on the disc appears steady, the image of the black spots on the retina gets mixed with the white spots and is sensed as brown.

Fig. 1 Disc exhibiting colours

Similarly, a white spot is seen as bluish as it gets mixed with the black spot.

When you observe a blue rotating disc in tubelight, it appears as blue with a tinge of pink in it.

Colour illusion

Our eyes may fail to detect the exact colour of a ' colour-spot ', by virtue of contrast, if the spot is surrounded by some other colour. This fact may be verified with a simple experiment as shown in Fig. 3 (p. 54).

Take two table-lamps with bulbs of equal wattage. Place them side by side to illuminate a white drawing paper (as a screen) in the front. Take a green gelatin paper and place it on one of the reflectors. Hang a ball as an obstacle so as to get two shadows A and B on the screen. Observe the colours of the shadows. The spot B which receives only green light will appear

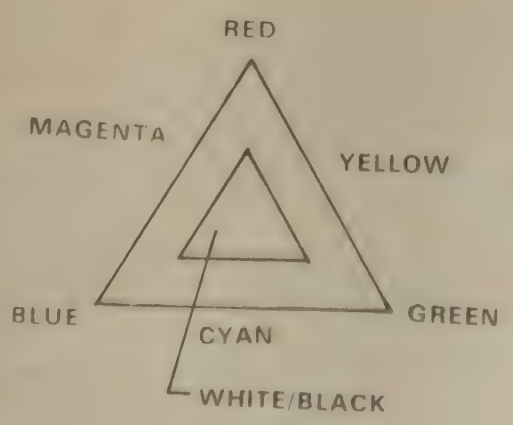


DIAGRAM OF
COLOUR TRIANGLE

RED + GREEN = YELLOW
BLUE + GREEN = CYAN
BLUE + RED = MAGENTA

Fig. 2 Complementary colours: At left is shown the colour triangle

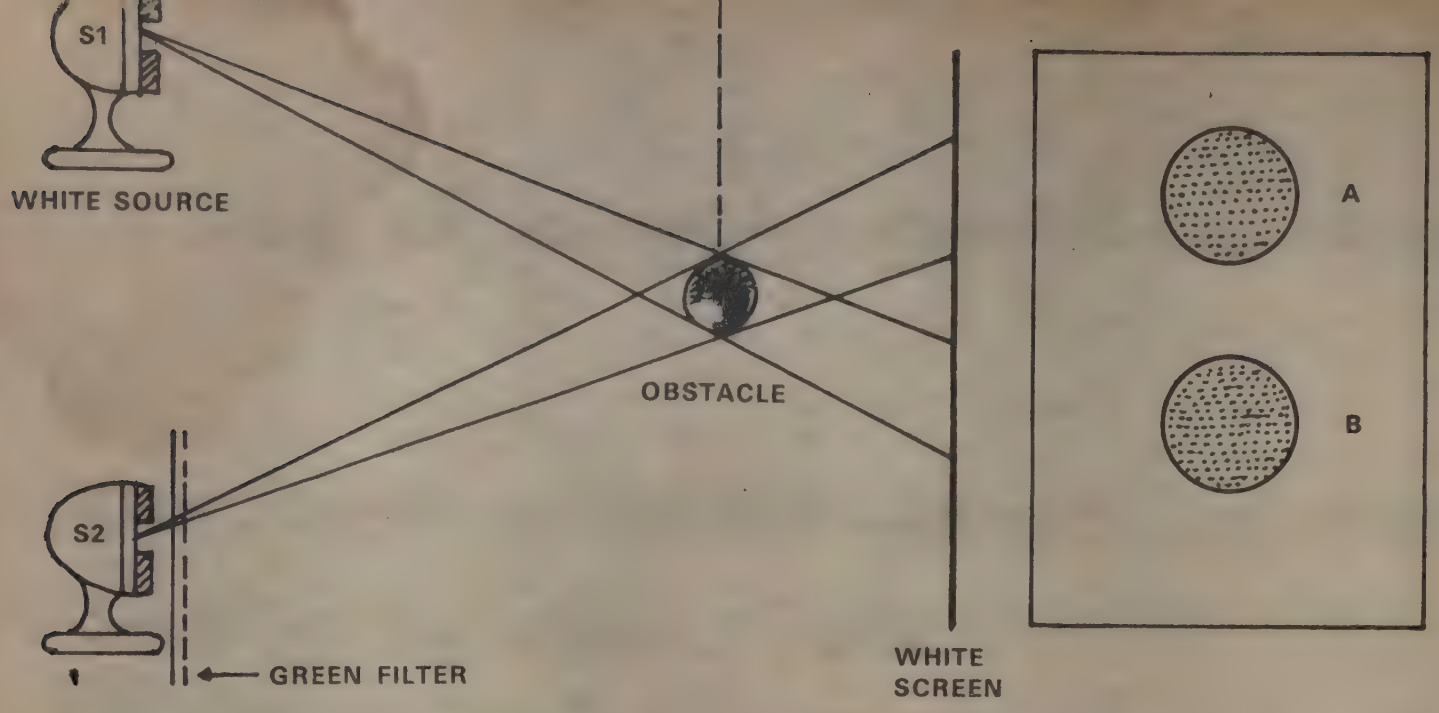


Fig. 3 Colour illusion. Spot A appears pink instead of white and spot B appears green

green, and the spot A which receives only white light will be seen as ' pink ' instead of white.

Suppose you use a red gelatin paper. Now the spot B will look red in colour and the spot A in green colour instead of white. The reason for the change in the colour of the spot A to pink or green can be explained as follows. The colours red and blue-green, when mixed together, produce white light and hence they are known as complementary colours. Other combinations of complementary colours are blue-yellow, magenta-green, white-black.

Complementary colours

From Fig. 2, we can find out the colours that are to be added to get a white colour. This process of getting white is known as the ' additive method '.

When the eyes are subjected to a bright light for some time, the retinal cones sensitive to these colours get tired. When the same retinal area is subsequently subjected to white light, the previously inactive cones respond more strongly than those originally stimulated and complementary colours are seen. Hence, we see a pink spot with green filter and a green spot with red filter.

Fig. 9 (A, B, C) on p. 56 shows some illustrations coloured with complementary colours. Observe them in bright light for 15 to 20 seconds keeping your eyes on a central spot. Then, immediately, turn your eyes on to a plain white paper. In a moment or two, the same picture will appear in the complementary colours.

Prepare some more illustrations of your own using the principle of complementary colours and observe them as in the above experiment.

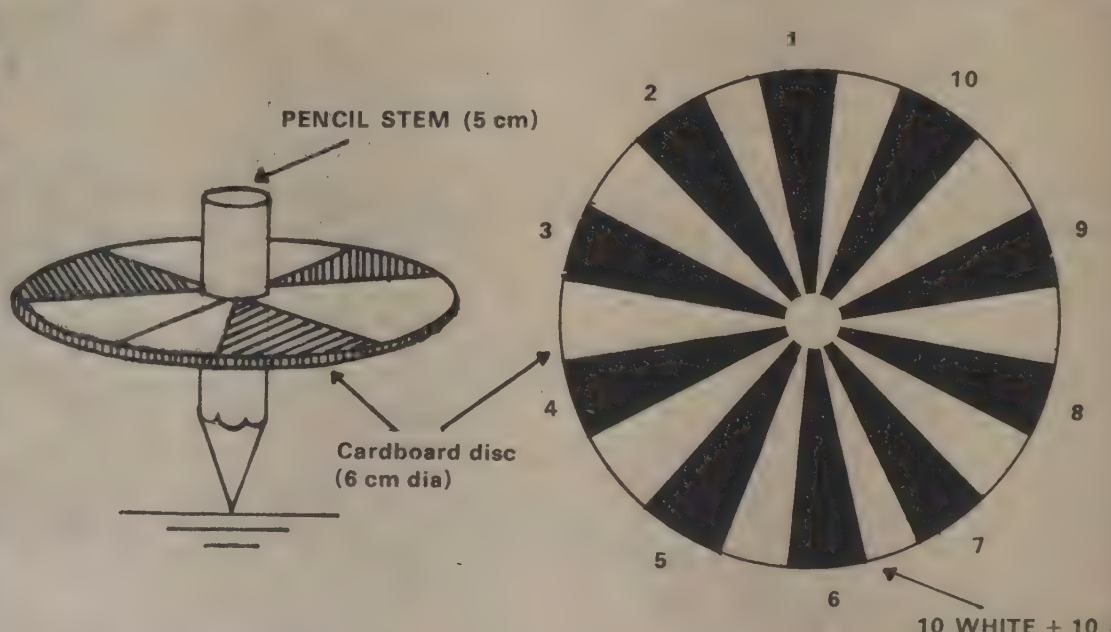
You may often have read a newspaper in bright sunlight. Have you ever felt the black print turning into coloured ones? Can you find out the reason?

Stroboscopic effect

You must have often seen it in the films: the spoked wheels of a chariot appear to turn sometimes forward and sometimes backward, though the chariot has been moving forward all the time. To understand the reason, let us perform a simple experiment with a table fan.

Switch on the fan and observe the rotation of the blades under a tube-light. The blades will appear to turn in the forward direction. Now, switch off the fan and the blades will appear to turn backwards. If you rotate the fan at higher speeds, you will observe the blades turn forward, stop and turn backward, though

Fig. 4 Spinning top as stroboscope

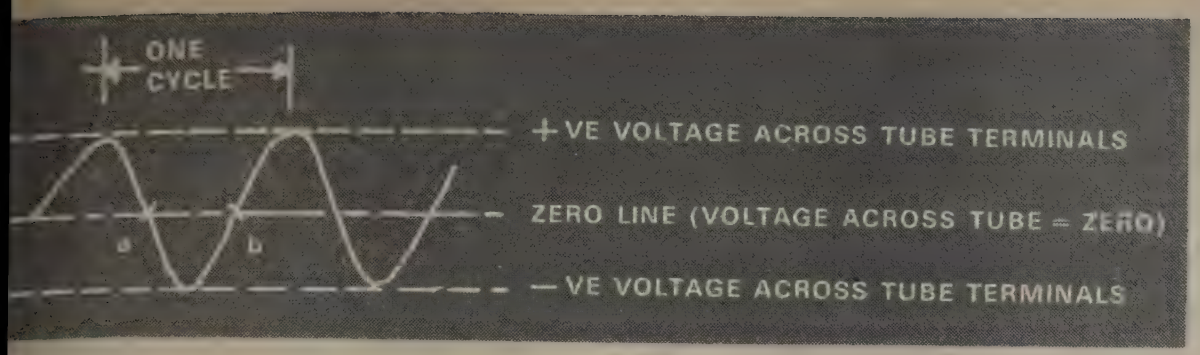


the fan is actually rotating direction only. This is kno the ' stroboscopic effect ' experienced when the freq of rotation of the blades ar frequency of the flickering illuminating source (the flic of the tube-light) differ.

Let us make a model st scope with a spinning top, a thick cardboard (3–4 mm t of about 6 cm diameter (Fi Use a thick nail or a pencil shaft, fixed tightly in the ho the disc's centre. Now cut a of 6 cm diameter with a ho the centre from a thick dra paper. Divide the circle int sectors and colour 10 alter sectors black. Place the dis the spinning top and rotat you observe the sectors in light, the disc will appea rotate forward and backward the fan blades.

The phenomenon may be plained as follows: the tube l gets the supply of alterna current with sine-wave form the frequency is of 50 cycles second (Fig. 5). From the fi it is seen that the tube rece voltage varying from + ve — ve alternately and it rece zero voltage twice in one c (at a and b in Fig. 5). Thus, tube receives zero voltage times a second (since the quency is 50 cycles per secon Thus, the tube light flickers times a second and works as interrupted source of light.

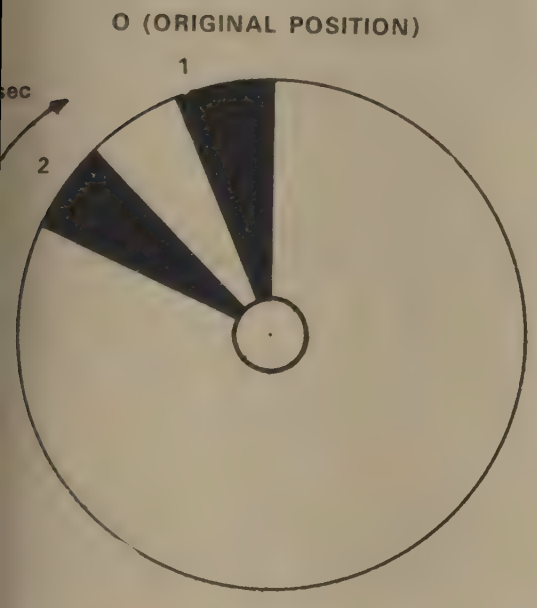
If the disc is rotated at revolutions per second, each tor will complete one rotation 1/10th second. Also, each sec will take 1/100th second to occu the position of the next sec (1/10th of 1/10th second — Fig. 7). Let us assume that sec 1 is at '0' (original position) wh the tube glows bright. Then, the next 1/100th second, secto



g. 5 Supply voltage changes at 50 Hertz per second

ll occupy the position of sector when the tube again glows ight. Similarly, after every 100th second, a new sector will cupy position '0' and tube will so give out bright light after ery 1/100th second.

Our eyes have retention power



g. 6 Stroboscopic disc. Sector 2 will ve to the position of sector 1 in 100th of a second; hence sector 1 will cupy its position in 1/10th of a second. ring each shift of position of the tors, light intensity is zero as voltage ero, and the shift is not noted by the eye

1/10th second; any fast motion king place in a shorter time an — less than 1/10th of a cond, are not noticed. Thus, e disc is seen as 'stationary' nen rotating at 10 revolutions r second. This speed matches e rate of interruptions of light peed of rotation of disc is nchronised with the frequency light). If the disc is rotated a tle faster, each sector will cupy a position *beyond* '0' in 100th second and the disc will seen to rotate forward.

Similarly, when the disc rotates a slower speed (less than the atching speeds), each sector will tate through an angle less than 0°, in 1/100th second and will *behind* '0' every time and the sc will be 'seen' to rotate ckward.

We can prepare a motorised- oboscope model using a dry ll motor to observe some inter-

esting disc patterns in tube light (Fig. 7). Fix a cell-motor on a wooden block (bracket) using a clip. Take the two leads to the dry cells — one direct and the other through a press switch. Cut a disc of 6 cm diameter out of a 3-mm-thick cardboard. Use an empty ball pen refill to extend the shaft and fix the disc tightly on this sleeve as shown in the figure.

Prepare the disc patterns of 6 cm diameter on drawing paper as shown in Figs. 8a, 8b and 8c. Fix the disc pattern (8b) on the cardboard disc (use gum or tape to avoid slipping of the paper disc). Rotate the motor and observe the disc pattern in tube light. The disc will seem to rotate forward, stop and reverse many times when the disc is speeding or stopping. Use a switch to speed up and to slow down the speed of the disc to maintain it near the matching speed where a steady pattern will be seen as if the disc is not rotating at all. The other disc pattern (Fig. 8a) will hardly be seen as steady since the matching speed for one concentric ring will not be the matching one for other rings.

Spoked wheels

In the motion pictures, a series of photographs are taken at the rate of 24 frames per second and are projected on the screen at the same rate of 24 frames per second.

Fig. 7 Motorised stroboscope

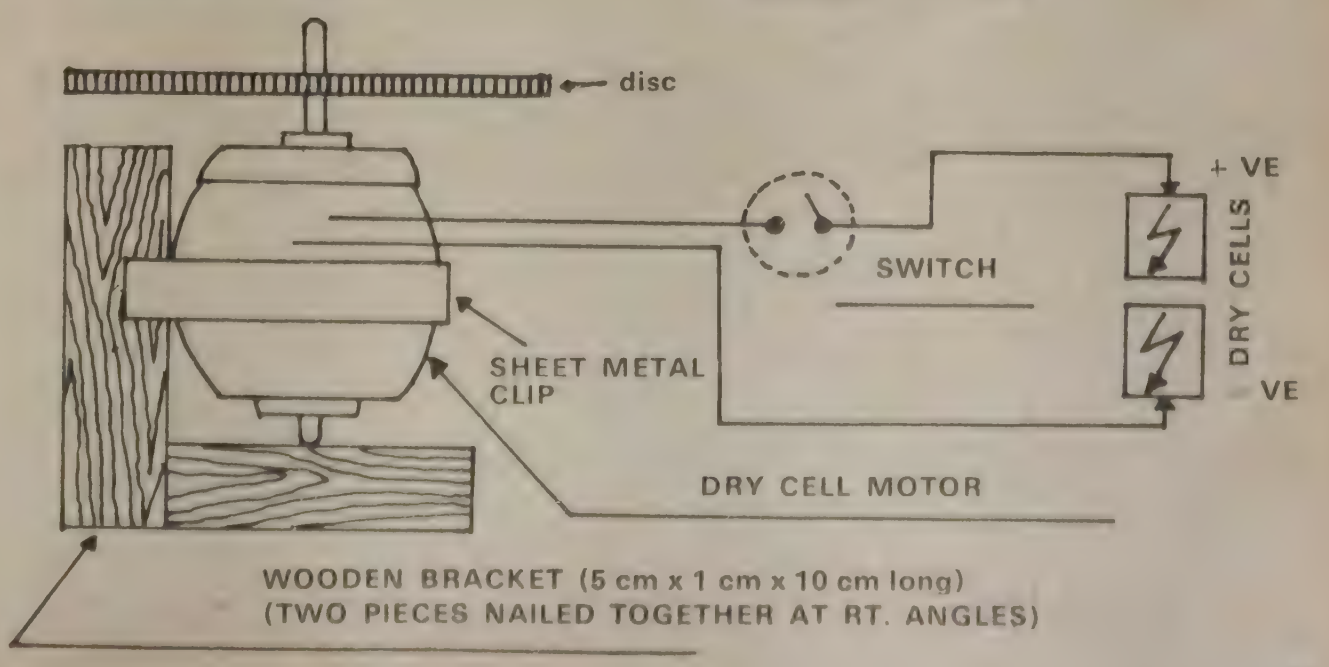


Fig. 8 Some discs to try on stroboscopes

(a) Three concentric circles with 3, 4, and 10 black divisions

(b) Single disc with six black sectors. You can also prepare discs with odd numbers of black divisions — 7, 13, 19, 23 — either single or in concentric circles as in (a)

(c) A disc with two spiral curves. The width of the black strip will gradually decrease over a turn

If the spoked wheel of a chariot rotates at a speed of 24 revolutions per second, the wheel will appear to be steady and not rotating. (If we take the number of arms of the wheel into account, then the wheel needs to rotate at a minimum speed of 24 revolutions per second to appear as steady.)

When the wheel rotates at a little higher or lower speed, it will appear as rotating forward or backward.

The rotating table fan also exhibits the same phenomenon of stroboscopic effect.

Switch on the table fan and let it run at its maximum speed and then switch it off. Observe the blade-rotation in tube light. You will observe the blades rotating forward, stop and reverse, repeatedly for three to four times, before the fan stops. Can you find out why this phenomenon is repeated three to four times when the fan speed is retarding?

NEXT MONTH:

MOIRE FRINGES

COLOUR ILLUSION

Fig. 9 Choose a spot at the central portion of these figures and observe for a few seconds in bright light and then immediately look at a bright white screen. In a moment or two, the same picture will ' appear ' on the white screen

LIGHTER MOMENTS

Newly hatched geese and ducks sider the first moving thing they as their mother and walk after it. Ko Lorenz, suspecting that the stimulus auditory, uttered duck-like quacks ne newly hatched clutch of mallards and promptly followed him. However, peeped about disconsolately when stood up, and he discovered that he to squat in order to present the right he to them.

One day, during an experiment, he waddling and quacking away wher group of tourists, to his discomfit happened to look over the fence and him. His peculiar behaviour must h appeared all the more insane to them the ducklings were hidden in the grass!

* * *

Linnaeus, in the tenth edition of *Systema Naturae* (1758), included orangutan in the same genus (*Hon* with man, calling it *Homo troglodyt* However, he grouped the gorilla under same species (*Homo sapiens*) as m calling it "wild man". His description the races of man is quaint:

Wild man — four-footed, mute, hairy.

Asiatic man — melancholy, rigid, seve greedy, discriminating. Governed opinions.

American man — erect, choleric, obstina gay, free. Lives by custom.

African man — crafty, indolent and neg gent. Governed by caprice.

European man — gentle, clever, inventiv Governed by rites.

A more arbitrary set of stereotypes c hardly be imagined.

* * *

In the 1870s, puritanism regarding s was more rigid than in today's permi sive era. Jean Henri Faber, like ma intelligent men, was an unconvention teacher, in that he admitted girls to h science classes, a thing unheard of the Although Napoleon the Third's minist of education was interested in this nov experiment, the local bureaucrats of Avig non, in Provence, where he taught, we aghast when they found that Faber's gi students were exposed to descriptions the fertilisation of flowers.

* * *

Charles Waterton the naturalist had th unusual habit of going to bed in th company of a four-metre boa constricto a sloth also shared his bedroom. And the he had a chimpanzee whom he neve failed to kiss goodnight!

* * *

When the naturalist Thoreau was lyin on his death bed, a religious aun visited him, and asked, "Henry, hav you made your peace with God? Thoreau's reply was to the point — "I di not know that we had ever quarrelled."

B. F. CHHAPGAR

NIVERSAL 500 WATT C. POWER CONTROL

his is the universal A.C. power control for adjusting A.C. voltage from zero to about 220 s. You can use this unit as a lamp mer, heater control, fan regulator peed control for universal motor. h this unit you will get introduced hree new electronic components ed diac, triac and quadrac. The rporation of a unique but simple klash-preventing circuit is an ed advantage over the available ly-made units of this type.

iac: Diac (Di[ode]ac) is a special of bi-directional trigger diode ing characteristics similar to a n lamp.

he voltage across the capacitor in relaxation oscillator (diagram on 3), while switching on the supply, is . The capacitor will start charging ough the 10 K resistor and it will se the voltage across it to increase. en this voltage reaches the break- voltage of the diac, usually veen 25 to 35 volts, the diac will ergo an avalanche breakdown will show negative resistance racteristics, ie, the current will ease as the voltage falls down. s peculiar action continues till the harging capacitor can provide cient current to continue the anche action and then the diac omes non-conductive again. The acitor once again starts charging the breakover voltage is reached the process continues. The graph (p. 63) illustrates the voltage across the capacitor and 33 Ohms resistor.

As the diac is a bi-directional device, it shows similar breakdown characteristics with either polarity of the applied voltage. Its three-layer construction is similar to a transistor, thus depending upon the polarity of the applied voltage, either of the two junctions is reversed biased and the diac remains non-conductive. When the breakover voltage is reached, with either polarity, the reverse biased junction undergoes avalanche breakdown. Thus, though a diac is basically a diode, it shows no similarity to the unidirectional flow characteristics of a conventional two-layer diode.

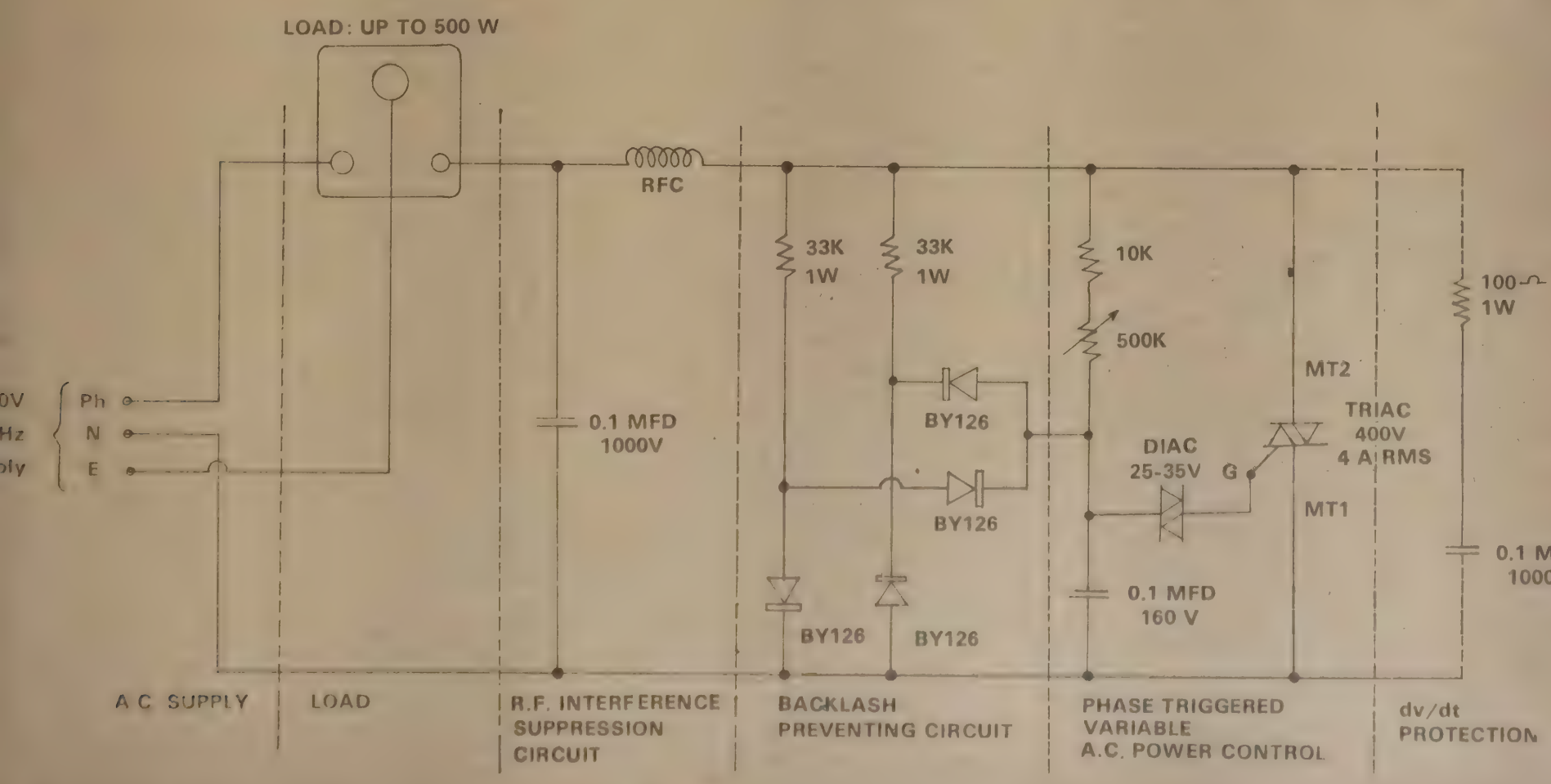
Triac: Triac (Tri[gger]ac) is an important member of the thyristor family. Like SCR, it has three electrodes: main terminal 1, main terminal 2 (also called anode 1, and anode 2 respectively) and the triggering electrode called gate. Unlike SCR, it is not a self-rectifier, as it can provide the current flow in either direction. The triac can be regarded as two SCRs connected in inverse parallel within a single device such that they share a single gate terminal. When no triggering signal is applied, the triac is non-conductive in either direction. Gate potential of one or two volts with current of a few milliamperes is sufficient to trigger a triac into conduction and allow several amperes of load current through MT 1 and MT 2. The triac may be triggered by gate current in either direction. The triac is very fast in action, taking hardly a few microseconds, when the gate is triggered, to turn into conduction. Once triggered, the gate has no control over the conduction. To make it non-conductive again, a current cutoff duration of a fraction of a millisecond is sufficient.

Quadrac: As in most of the phase-triggered variable A.C. power control applications, a triac is used with a diac, a single device combining both of them, i e, a diac built into the gate of the triac, in a single package is available and is called a quadrac. The symbol of quadrac also illustrates the same thing. In the construction of this unit you may use either a single quadrac or a separate diac and a triac.

The circuit diagram shown below basically consists of 1) RFI (radio frequency interference) suppression circuit 2) Backlash preventing circuit 3) Phase triggered variable A.C. power control and 4) dv/dt protection for the triac when the unit is used with inductive loads.

The RFI suppression circuit is necessary mainly with resistive loads, viz, lamps and heater, as the high rate of change of current, di/dt, provided by the triac while controlling the power, causes interference in amplitude modulated broadcast of radio and TV picture transmission.

The backlash preventing circuit is necessary with resistive or inductive loads as it provides identical capacitor charging and discharging condition, for every half cycle and thus avoid,



From Alchemy to to-day's Science

Alchemy began by an obsessive urge for transforming the baser metals into gold. The alchemists never succeeded in making gold from base metals, yet their experiments recorded under mystic terminology, gradually led to the discovery of metallic arsenic, antimony and phosphorus.

The pale light of phosphorus began to illumine the dark secrets of alchemy and led to the steady advance of modern scientific chemistry.

We at Sarabhai M. Chemicals have an obsession of alchemists, not for producing 'Philosopher's Stone' but for providing an ever increasing range of ultra high purity and trustworthy laboratory reagents—the tools of modern chemists for the advancement of science.

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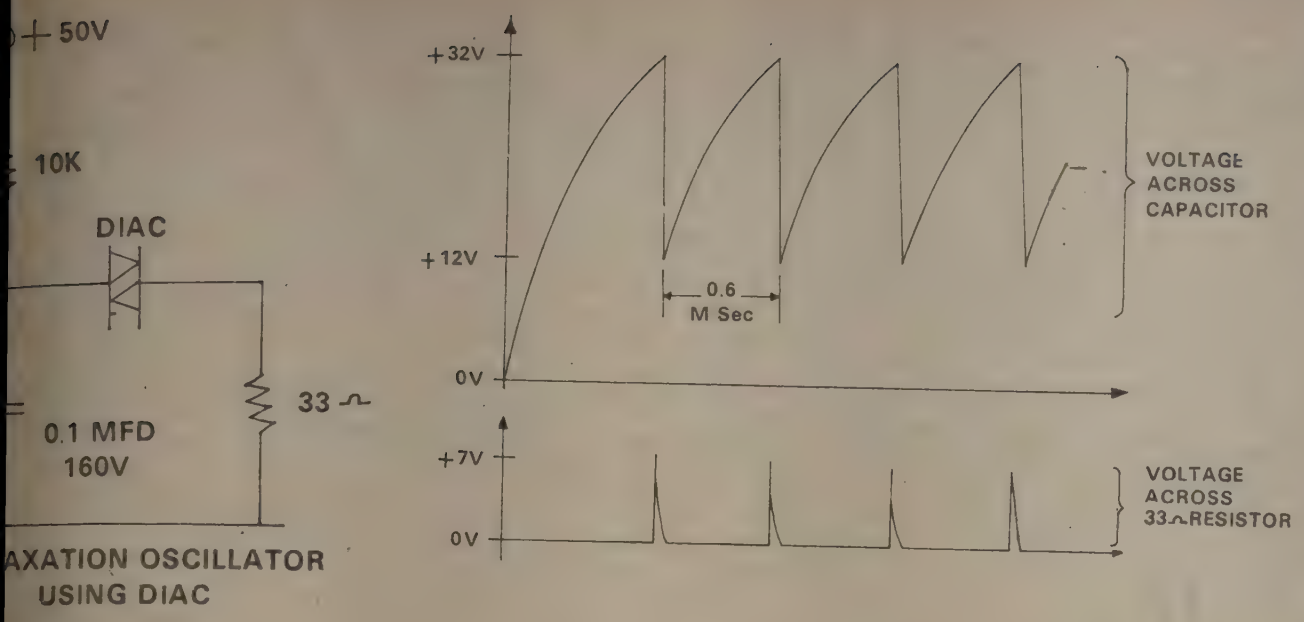


AXATION OSCILLATOR USING DIAC

klash (also called snap-on or teresis). This behaviour is asso-ted with the basic phase triggered C. variable power control without type of preventing circuit. (With basic circuit with the lamp load, you increase the resistance of the entiometer, the lamp will become and, for a certain value of resist-e, say 480 K, it may just go com-tely off. Now, if you lower the stance, the lamp may not light till resistance is lowered considerably he value, say 400 K. When the p lights up, it will do so with den brightness without a smooth ease in intensity. This 'snap-on' on is called backlash.)

The phase triggered variable A.C. power control circuit is the basic circuit of the unit. The variable resistor controls the rate of charging of the capacitor and thus provides variable phase delay. You may have to increase the value of the timing capacitor, by parallel combination, up to 0·15 mfd to get full span of the variable resistance. The diac acts as a trigger device. When the capacitor charges to the breakover voltage of the diac, the diac comes in to conduction and discharges the capacitor through the gate of the triac. Thus, the triac gets triggered and the current flows through the lamp. When the zero crossing of the mains A.C. supply occurs, the triac becomes non-conductive and the capacitor starts charging again and the process is repeated.

The triac or quadrac should be mounted on 5 cm × 5 cm aluminium or copper plate serving as a heat-sink. This heat-sink should be kept electrically isolated from the rest of the components and enclosure.

The rate of rise of voltage across the triac, dv/dt, while using the unit, mainly with inductive loads, viz, fan or universal motor, becomes very high. Thus, to reduce the dv/dt, a RC series network is provided across the triac.

You will need:

Triac: 4 Amps RMS, 400V, 1 no.
Diac: 25 to 35V, 1 no.
BY 126 or *BY* 127, 4 nos.
Capacitors: 0·1 mfd — 1,000V DC, 2 nos.; 0·1 mfd — 160V DC, 1 no.
Potentiometer: 500 K carbon linear, 1 no.
Resistors: 33 K 1W, 2 nos.; 100 Ohms 1W, 1 no.; 10 K 1/2W, 1 no.
(Approximate cost of electronic components only : Rs. 60.)
RFC: About 150 turns of 24 SWG enamelled wire over a non-metallic former of about 10 mm diameter.
Misc: 3 pin 5 Amps mains socket, lugstrips or groupboards or veroboards, screws, wires, solder, knob, suitable enclosure, aluminium or copper plate, 5 cm x 5 cm, etc.

ANIL V. BORKAR

MINISTRY OF HOME AFFAIRS

DEPARTMENT OF PERSONNEL AND ADMINISTRATIVE REFORMS

. . . . . .

Assignment of Indian Experts Abroad

The Department of Personnel and Administrative Reforms register/experts with educational qualifications of the graduate level and above desiring to take up assignments in the developing countries of Asia, Africa and Latin America, for a period of two to three years. Candidates who are so registered are sponsored as and when demands suiting their qualifications and experience are received from foreign governments.

2. Applications for registration are invited from:—

(1) Medical personnel holding at least the qualifications of M.B.B.S. or equivalent.

(2) Engineering and other technical personnel holding at least bachelor's degree or equivalent.

(3) Teachers in different subjects holding B.Ed. or equivalent.

(4) College/University Lecturers and other academic personnel holding post-graduate qualifications.

(5) Chartered Accountants, Statisticians, Economists and others possessing qualifications equivalent at least to a bachelor's degree and experience of a specialised nature.

3. Persons with less than three years' professional experience after obtaining the requisite qualifications need not apply.

4. Experts wishing to be enrolled in the Foreign Assignment Panel may obtain the necessary forms from the Foreign Assignment Section, Department of Personnel and Administrative Reforms, New Delhi-110001, by sending a self addressed, stamped (60 paise) envelope size 10 X 22 cms. Applications from persons employed by the Central or State Governments, Public Sector Undertakings, Universities and Quasi-Governmental Organisations should be supported by a certificate from the employer that the applicant will be released for service abroad on foreign service terms in public interest (i.e. retaining the applicant's lien and protecting his seniority) within thirty days of selection, if need be, and also stating the total period for which the applicant could be released for service abroad. This consent of the employer to the release of the expert shall be valid for a period of one year. Registration of candidates made prior to 1st September, 1974 is no longer valid and they may apply afresh.

5. Persons registered after 1st September, 1974 need not apply afresh until the expiry of three years from the date of registration, when their registration will lapse.

6. These registrations will be valid for a period of three years subject to annual renewal of the certificate described above in the case of employees of Governments of parastatal organisations etc.

7. Persons who have attained the age of 60 years need not apply. Applications of persons registered earlier will also not be considered after they attain the age of 60 years.

davp 561 (EN—25)/77

TELL US WHY...

. . shiny things are ooth?

ictly speaking, not all shiny objects mooth to the touch, for example, the of 'glittering crusty' materials. But on ination we find that such materials nt many tiny smooth surfaces to the rver. It is these smooth surfaces that e, so such cases do not violate the rule shiny things are smooth. The converse, ever, is not true. It is not difficult to of objects with smooth yet dull ces, for instance, the outside of a gun l. But the qualities of smoothness and ness are conceptually quite distinct, referring to the sensation of touch, other to sight. So it is interesting to stigate the connection between the and ask why they often go together.

t us begin by investigating terms. An ct is said to be smooth if on feeling its ace, one cannot discern surface irregula-. But we may note that there are s to the sensitivity of our touch ors, which probably have to do with spacing between nerve endings at the er tips, and the frequency at which the e cells can fire. Thus, many smooth cts may reveal considerable irregularity n examined under a microscope.

hat do we mean by shiny? This is a more difficult to define, though ybody knows what it means. All will e that a mirror is shiny. The concept omes clear if we examine how artists ct shiny objects — by the clever use of shading to appropriately place a few 'bright spots' on the object. If we now turn to examine an actual shiny object, for instance, another person's eye, we will notice that these bright spots, or localised regions of brightness, are just the reflected images of some extra bright light sources in the environment, for example an open window, a light bulb, or the sun. It is only in non-uniform illumination that we can discern the property of shininess. The most highly polished silver mirror would not shine if it were seen under conditions of perfectly uniform lighting from all sides.

Thus a shiny surface is one which reflects such that the image of a concentrated source of light is also concentrated. It may distort the shape and size of the object, but otherwise there is more or less fidelity in reflection, corresponding to more or less shininess. Not only is a mirror a shiny object, but the converse is also more or less true. On the other hand, a dull surface like a whitewashed wall reflects a concentrated source as a diffuse blob with ill-defined boundaries, if any. It remains now to establish the connection between surface regularity and fidelity in reflection.

A simple experiment illustrates the principle involved. It can easily be performed in a tub, or large basin filled with water. Plane waves of a definite wavelength (the distance between two crests of the wave train) can be produced by floating a footrule at one end of the tub and bobbing it up and down at a definite frequency with your finger. These waves will propagate down the length of the tub where they should be allowed to reflect off variously shaped walls which can be made of cardboard or plastic sheet. The form of the reflected wave should then be observed. When the wall is smooth, or when the surface irregularities are small in comparison with the wavelength, the reflected wave is a good copy of the incident wave, except for some overall change in shape. But when the wall irregularities are comparable to the wavelength of the incident wave, the reflected wave is a jumble of little waves that travel in all directions. In the last case where the non-uniformities of the wall are much larger than the wavelength (but each non-uniformity itself has a smooth surface), the reflected wave consists of a few large pieces each of which resembles the incident wave.

It is a well-known fact that light consists of electromagnetic waves with wavelengths between 4×10^{-5} cm and $7{\cdot}5 \times 10^{-5}$ cm. Any light source then emits a series of waves which contain (in subtle manner which we cannot discuss here) all the information about the source which can be obtained visually. These waves are reflected by the various objects that we see around us. Mirrors produce reflected waves which are much like the incident wave. From the discussion in the preceding paragraph, we conclude that a surface will act as a mirror (that is, it will be shiny) if its surface irregularities are considerably smaller in size than the wavelength of light, that is, much smaller than 10^{-5} cm. Dull surfaces have little bumps which are comparable in size to the incident wavelengths. The last case corresponds to crusty glittering materials.

It is easy to understand now the role that polishing plays in producing shiny surfaces. It removes the irregularities, progressively reducing them in size, till they are smaller than the wavelengths of visible light.

VIVEK MONTEIRO

BRAIN TEASERS

IX-UP: I was teaching textile processing to my students. I explained the ortance of five trade products used in g, bleaching, dyeing, printing and hing (one in each). Next day I took a surprise test and told them to write down the names of the products used in the various processes. It seems they got them all mixed up. Four of the students wrote as in the table below.

Each of these students was correct about at least one product and no two of them were correct about the same number of products. Who was all-correct?

V. A. SHENAI

(Solution next month)

tudent	Sizing A	Bleaching B	Dyeing C	Printing D	Finishing E
I	Dengo	Bengo	Engo	Ango	Cengo
II	Engo	Ango	Cengo	Dengo	Bengo
III	Ango	Bengo	Cengo	Dengo	Engo
IV	Ango	Bengo	Dengo	Cengo	Engo

Solution to last month's Brain Teaser

ost in transit

Let n copies be sent in the first consignment. Then the second one had n^2 opies and the third, n^4 copies, and $^4 - n^2$ were delivered. It is to be ound out whether this last number is ivisible by 12.

Now $n^4 - n^2 = n^2(n^2 - 1)$

$= n^2(n + 1)\ (n - 1)$

$= (n - 1)\ n^2(n + 1)$

Since this contains the product of three consecutive numbers, it is divisible by 3. If n is even, n^2 is divisible by 4. If n is odd, $n + 1$ and $n - 1$ are both even. In this case also, the entire product is divisible by 4. Hence, it is divisible by 12. So the retailers got the copies.

BOOKS

(*Contd. from p. 51*)

upon the "total rehabilitation" of stroke cases keeping in view their emotional, intellectual, educational, vocational and social background for readjustment. This is a much neglected topic and merits serious consideration.

Annexed in this book are exhaustive charts on stroke registry and compressive medical and nursing management as practised in North Carolina, USA. It appears that each community will have to evolve its own programme on total management of stroke cases after taking into account the magnitude of the problem, available resources and several "local factors".

The book may appear as a heterogenous compilation and certainly lacks the clarity and smooth reading of any standard text-book. Nonetheless, it contains very valuable and comprehensive information. It will remain a recommended companion for years for hospitals, medical libraries and public health authorities.

P. M. DALAL

[Dr. Dalal heads the Neurology Department, B. Y. L. Nair Hospital, Bombay.]

AWARDS & APPOINTMENTS

nanna re-elected INSA sident

R. Raja Ramanna, Director, Bhabha ic Research Centre, has been re-ed President of the Indian National nce Academy. Prof. R. C. Mehrotra, -chancellor, University of Delhi, and A. K. Sharma, Head, Department of ny, Calcutta University, have been ected vice-presidents.

e Academy has elected 30 new ws and five new foreign Fellows. They Prof. S. Dhawan, Chairman, Indian e Research Organisation, New Delhi, Director, Indian Institute of Science, galore, Prof. S. C. Agarwala, Head of Department of Botany, Lucknow ersity, Lucknow, Dr. A. B. Biswas, rtment of Chemistry, Indian Institute Technology, Bombay, Prof. B. B. as, Professor of Plant Biochemistry, Institute, Calcutta, Prof. V. L. S. asankaram, Head, Centre of Explora- Geophysics, Osmania University, rabad, Dr. S. Chandrasekhar, Liquid tal Laboratory, Raman Research Insti- Bangalore, Dr. R. Chidambaram, , Neutron Physics Section, Bhabha ic Research Centre, Bombay, Prof. Chopra, Dean, Faculty of Science, Delhi, Dr. B. Choudhury, Head, Division egetable Crops and Floriculture, Indian cultural Research Institute, New Delhi, Asok Ghosh, Sir Nil Ratan Sircar essor of Zoology, Calcutta University, utta, Prof. P. C. Jain, Senior Professor athematics, Indian Institute of Techno- Bombay, Prof. G. S. Khush, Head, tal Improvement Department, Inter- nal Rice Research Institute, Manila, S. C. Maheshwari, Head, Department of ny, University of Delhi, Delhi, Prof. H. Y. an Ram, Professor of Botany, Univer- of Delhi, Delhi, Dr. B. R. Nag, Institute adio Physics and Electronics, Calcutta, D. Nasipuri, Professor of Chemistry, Kharagpur, Prof. C. C. Patel, Professor norganic & Physical Chemistry, Indian tute of Science, Bangalore, Prof. P. P. aroty, Physical Research Laboratory, edabad, Prof. Prem Narain, Professor tatistical Genetics, Institute of Agricul- Research Statistics, New Delhi, Prof. N. Radhakrishnan, Professor of Bio- nistry, School of Life Sciences, erabad University, Hyderabad, Dr. S. navan, Associate Professor, Tata Insti- of Fundamental Research, Bombay, V. S. Ram Das, Head, Department of ny, Sri Venkateswara University, Tiru- Prof. M. R. Rajasekharasetty, Head, artment of Post-Graduate Studies and earch in Zoology, University of Mysore, ore, Prof. K. N. Sharma, Chairman and essor of Physiology, University College Medicine, New Delhi, Dr. A. P. B. a, Deputy Director, National Chemical oratory, Pune, Prof. M. S. Sodha, artment of Physics, IIT, New Delhi, E. C. Subba Rao, Department of Metallurgical Engineering, IIT, Kanpur, Prof. R. N. Sukheshwala, Department of Geology, St. Xavier's College, Bombay, Dr. S. Swaminathan, Department of Organic Chemistry, Madras University, Madras, and Prof. J. P. Thapliyal, Department of Zoology, Banaras Hindu University, Varanasi.

The foreign Fellows are: Prof. Sir Derek Barton, Professor of Organic Chemistry, Imperial College of Science and Technology, London, Prof. Jacques-Emile Blamont, Director, Scientifique et Technique du Centre National d' Etudes Spatiales a sa Foundation, Paris, Prof. Herbert C. Brown, Purdue University, USA, Prof. Ochoa Severo, Department of Biochemistry, New York University School of Medicine, New York, Dr. Jamshed R. Tata, Head of Division of Developmental Biochemistry, National Institute for Medical Research, London.

The members of the Council are: Dr. F. Ahmad, Commissioner, Mines and Geology, Government of Jammu & Kashmir, Jammu/Srinagar (new member); Dr. D. P. Antia, Calcutta (new member); Prof. A. Bose, West Bengal; Prof. J. Ganguly, Head of Advanced Centre of Biochemistry, Indian Institute of Science, Bangalore; Dr. J. S. Kanwar, Associate Director, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad (new member); Dr. C. R. Krishna Murti, Deputy Director, Industrial Toxicology Research Centre, Lucknow (new member); Prof. N. Balakrishnan Nair, Head, Dept. of Aquatic Biology & Fisheries and Dean, Faculty of Science, University of Kerala, Trivandrum (new member); Prof. M. S. Narasimhan, School of Mathematics, TIFR, Bombay; Dr. Y. Nayudamma, Central Leather Research Institute, Adyar, Madras; Dr. A. S. Paintal, Director, V. P. Chest Institute, University of Delhi (new member); Dr. N. Parthasarathy, Madras; Prof. V. Puri, Professor Emeritus, Institute of Advanced Studies, Meerut University, Meerut; Prof. C. N. R. Rao, Solid State & Structural Chemistry Unit, Indian Institute of Science, Bangalore; Prof. S. N. Sarkar, Head, Department of Applied Geology, Indian School of Mines, Dhanbad; Prof. G. P. Sharma, Head, Department of Zoology, Punjab University, Chandigarh; Dr. K. Sundaram, Director, Biomedical Group, Bhabha Atomic Research Centre, Bombay; Prof. S. K. Trehan, Professor of Applied Mathematics, Punjab University, Chandigarh; Dr. H. V. K. Udupa, Director, Central Electro-Chemical Research Institute, Karaikudi.

Awards to young scientists

Fourteen scientists have been awarded the Science Academy medal for Young Scientists. They are: Dr. Ateeq Ahmad, Division of Biophysics, Central Drug Research Institute, Lucknow (for his contribution to a novel method for purification of glycoproteins enzymes), Dr. P. Balaram, Molecular Biophysics/Structural Chemistry Unit, Indian Institute of Science, Bangalore (contribution to the application of modern spectroscopic methods to the study of complex biological systems), Dr. Asha Chandola, Department of Zoology, Banaras Hindu University, Varanasi (iodine metabolism in sub-mammalian vertebrates), Dr. S. K. Dattagupta, Reactor Research Centre, Kalpakkam, Tamil Nadu (work on stochastic theory of line shape), Dr. S. K. Dubey, Department of Biochemistry, All-India Institute of Medical Sciences, New Delhi (work on immunological properties of conjugated human chorionic gonadotropin), Mrs. V. P. Joshi, Biology and Agricultural Division, Bhabha Atomic Research Centre, Bombay (original contribution in DNA damage, repair and recombination mechanisms in *H. influenza*), Dr. S. C. Kak, Department of Electrical Engineering, Indian Institute of Technology, New Delhi (work on communication of signals), Dr. A. S. Raghavendra, Department of Botany, Sri Venkateswara University, Tirupati (contribution in physiology and biochemistry of stomatal movement and a better understanding of the C_4 photosynthesis), Dr. R. K. S. Rathore, Department of Mathematics, IIT, Kanpur (contribution to approximation theory), Dr. N. M. Singhi, School of Mathematics, Tata Institute of Fundamental Research, Bombay (combinatorial mathematics in field of designs), Dr. H. Sinvhal, Department of Geology & Geophysics, University of Roorkee, Roorkee (microseismicity and strain measurements), A. K. Suri, Metallurgy Division, BARC, Bombay (technology of rare and refractory metal extraction), Dr. R. C. Sobti, Department of Zoology, Punjab University, Chandigarh (karyotypic diagnosis and prognosis of human disorders, particularly the neoplasia), Vijay Kumar, Seismology Section, BARC, Bombay (development of indigenous instruments for locating atmospheric explosion).

The awards, instituted in 1974, are given to scientists below 30, for scientific achievements. The award carries a cash prize of Rs. 1,500 each, and a research grant of Rs. 5,000 each from the Kothari Scientific and Research Institute, Calcutta.

Fellowship in environmental sciences

The first fellowship in environmental sciences of the Department of Science and Technology has been awarded to Dr. Anil Kumar Ganguly, Director of the Chemical Group of the Bhabha Atomic Research Centre, Bombay. Dr. Ganguly will study the application of nuclear techniques and prediction modelling investigations on the movement of aquatic and crustal material of the Earth's surface and environmental problems in relation to industry. The two-year fellowship carries Rs. 2,500 per month and Rs. 10,000 per year for research work and Rs. 5,000 for contingent expenses.

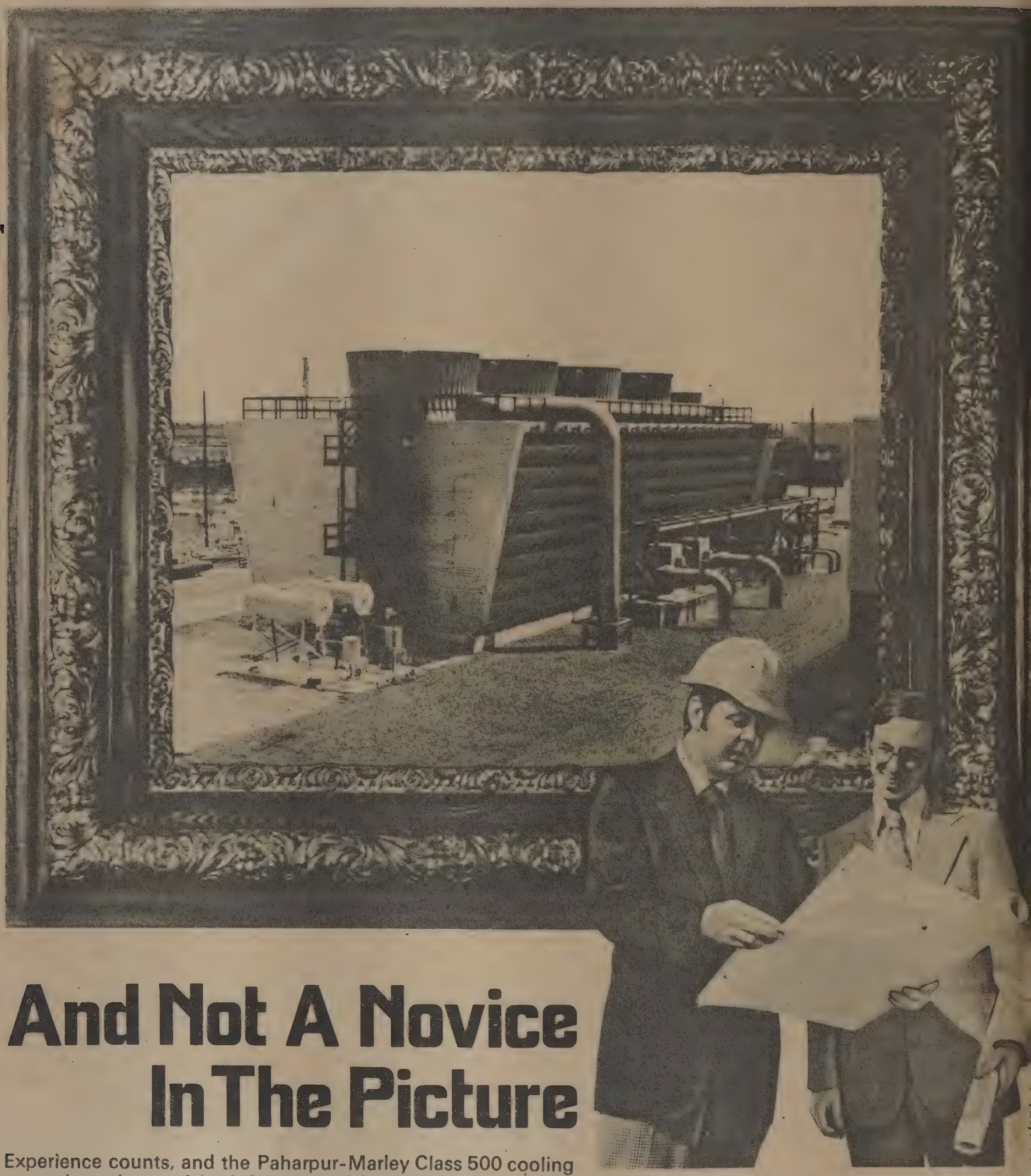
IUPAC election

Prof. C. N. R. Rao, Indian Institute of Science, Bangalore, has been elected to the Bureau of the International Union of Pure and Applied Chemistry.

Achaya to be consultant

Dr. K. T. Achaya, Executive Director of the Protein Foods Association of India, Bombay, has been appointed Consultant, UN University Programme, at the Central Food Technological Research Institute, Mysore.

34 Frame Sizes



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As a vital industry that helps keep the wheels of progress moving, it would seem that IBP was sufficiently involved in the nation-building process to confine its energies to improvements and growth in its own particular field of petroleum. But IBP's philosophy is total commitment—to a broader, more comprehensive objective. It's technological know-how and expertise is available to help develop and modernise other industries, specially in rural, tribal and less-developed areas; to create much-needed employment opportunities; to bring the modern and sophisticated technology to the remotest regions and people. The ultimate test of an organisation's commitment to the overall good of the country lies in its contribution to the growth and progress of even directly competitive industries.

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A stake in India's overall growth

With IBP's entry into explosives, India's mining and construction industries will find it easier to expand, operate more economically and with greater safety. Creating much-needed employment opportunities in rural areas.

All this, while thousands of vehicles are refuelling at more than 700 IBP retail outlets across the country. After all, IBP is synonymous with petroleum, even while it has a stake in India's multi-directional search for alternative energy sources.

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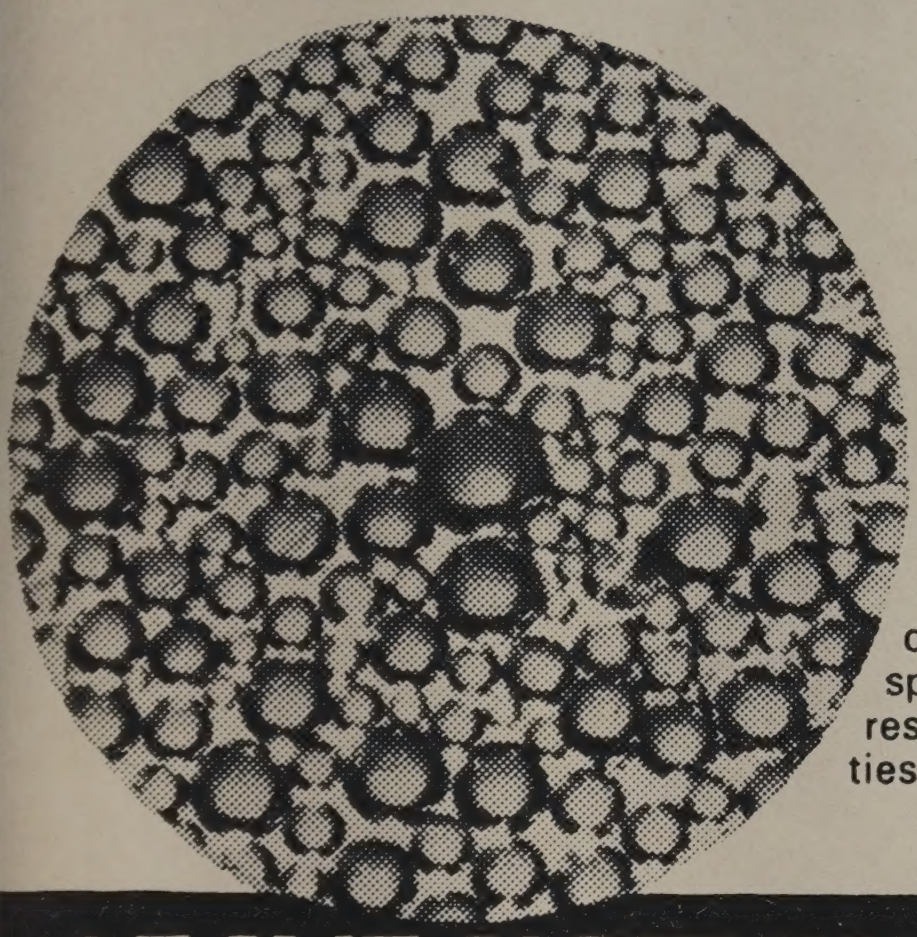
A Government of India Enterprise



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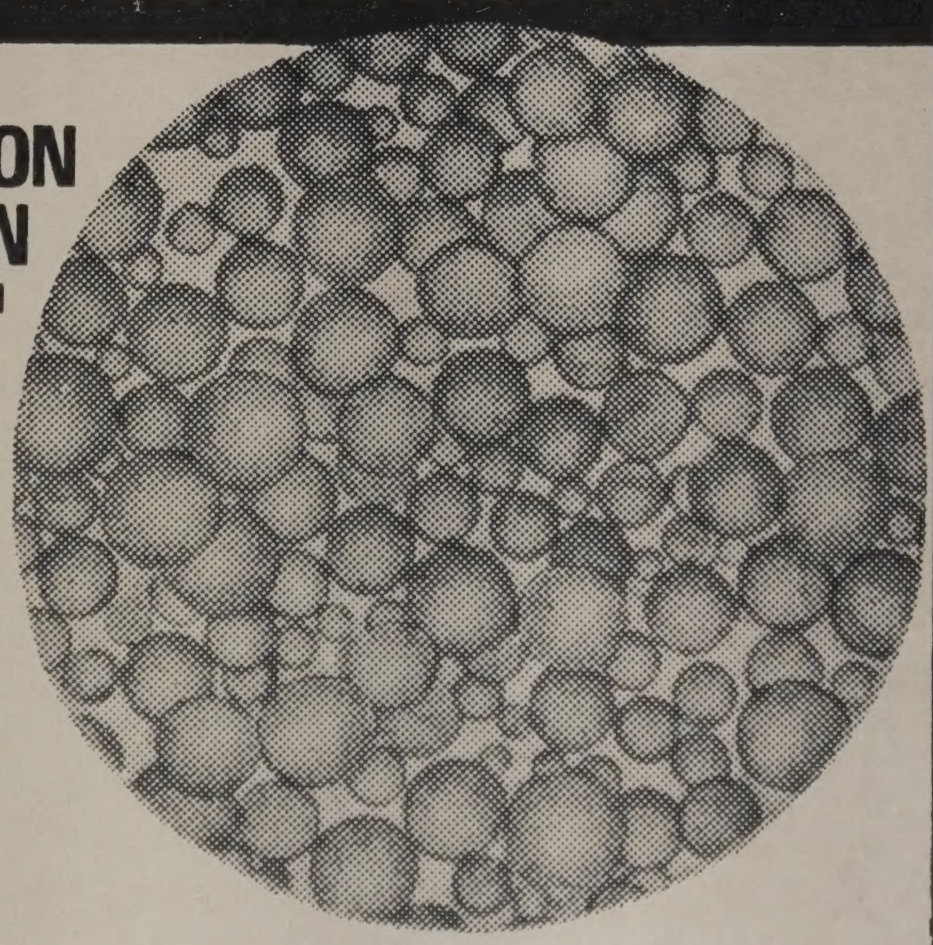

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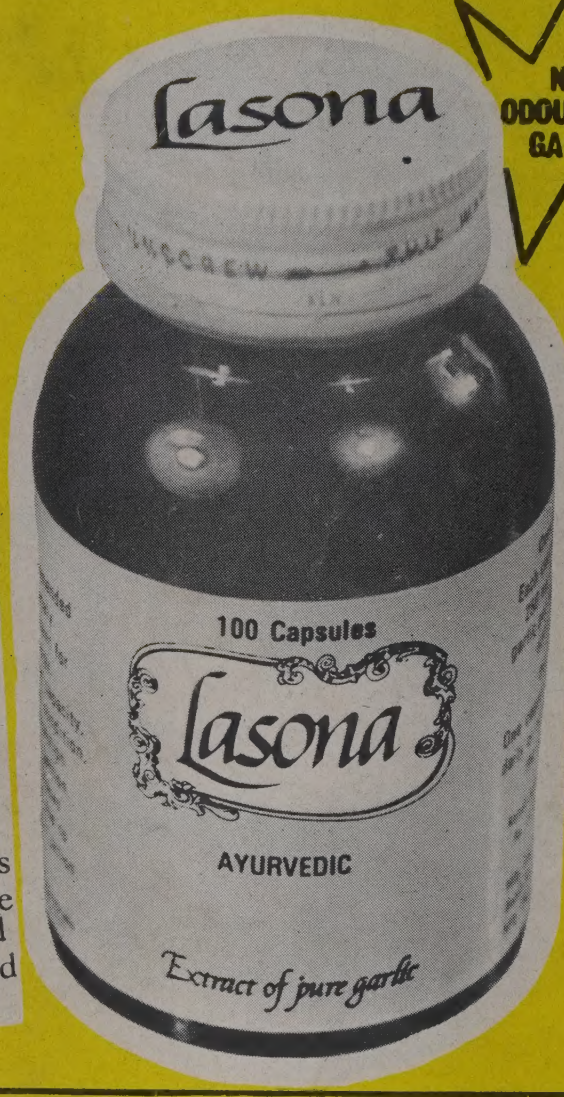
SUNDAY STANDARD
Vijayawada, Sunday October 17, 1976

Raw Garlic is anti-bacterial

NAINI TAL Oct 29 (Samachar)

Raw garlic possesses anti-bacterial property against a number of micro-organisms including those which are resistant to commonly used anti-biotics. This is revealed in researches conducted at the Pantnagar University. According to the researchfindings, anti-bacterial property of garlic is lost on boiling.



THE TIMES OF INDIA
BOMBAY, DEC. 3-1976

Eat Garlic and Cut Cholestrol

NEW DELHI, December 2: A medical study has revealed that garlic is effective in reducing blood cholestrol. An experiment by Dr. R.C. Jain, pathologist at the University of Benghazi in Libya has now shown that garlic reduces the cholestrol level.

He did the experiment on rabbits which he fed with a diet containing large amounts of Cholestrol for 16 weeks. Their aorta (main blood vessel) and liver were deposited with cholestrol but after giving them garlic, he noticed that the fat dissappeared and the blood cholestrol came down. Dr. Jain has reported the results of his experiment in "The Journal of Indian Medical Research". How exactly garlic brings down cholestrol level is, however, not clear, Dr. Jain said-Samachar.

Eve's Weekly
July-17-1976

AYURVEDA IN YOUR HOME

Suresh Chandra Chaturvedi

GARLIC

Regular use of garlic helps the digestive system and removes gas and constipation. It increases the blood, cures chronic cold and cough Gastric troubles are cured by taking garlic every day.

ACTUAL SIZE  EASY TO SWALLOW

The best way, the original way and now the modern way, of taking garlic in its purest and most palatable form is LASONA garlic pearls. These are capsules of garlic oil which are absolutely tasteless and odourless, dissolving only when they have reached the stomach. So now you can have all the benefits, all the advantages of garlic without any of the taste and odour problems. And the benefits of taking LASONA garlic pearls regularly are immense. They fortify the body so it can deal vigorously with a wide variety of common ailments before they can take hold. There is nothing finer as a natural antiseptic and purifier, and to give all-year-round protection against infection.
Take one LASONA garlic pearl after each main meal as part of your regular diet.

SPECIALLY FORMULATED Lasona. Extract of pure garlic

Completely eliminates the offensive odour of raw garlic and benefits you in more ways than one by,

✿ Reducing cholesterol ✿ Improving your digestion ✿ Relieving gas ✿ Purifying the blood ✿ Helping to clear persistent long standing coughs

Lasona – the sure, safe and completely natural way to better health and happiness.

Now freely available at leading chemists and better stores in your town

Thomas Pharmaceuticals Private Limited 23 Hamam Street, Bombay 400 023